



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

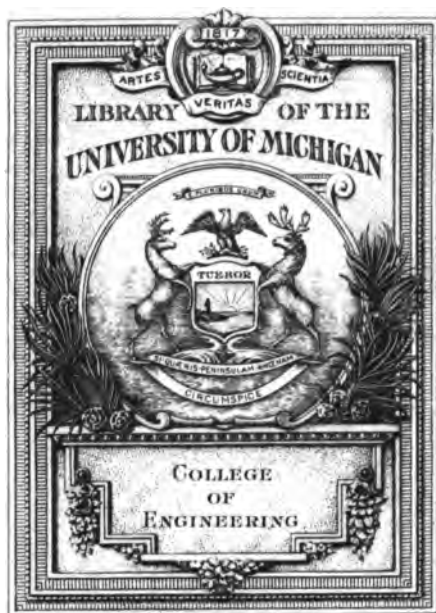
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

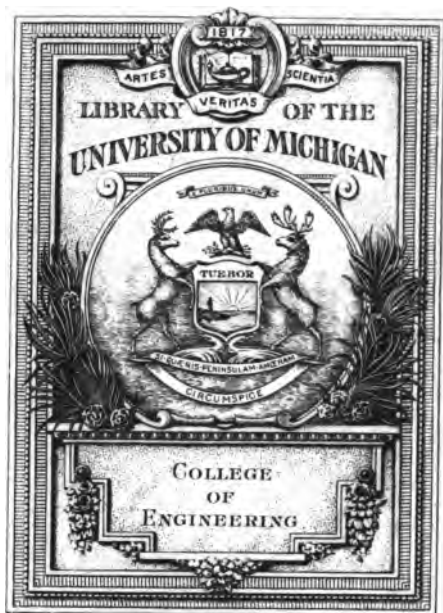
A

749,909

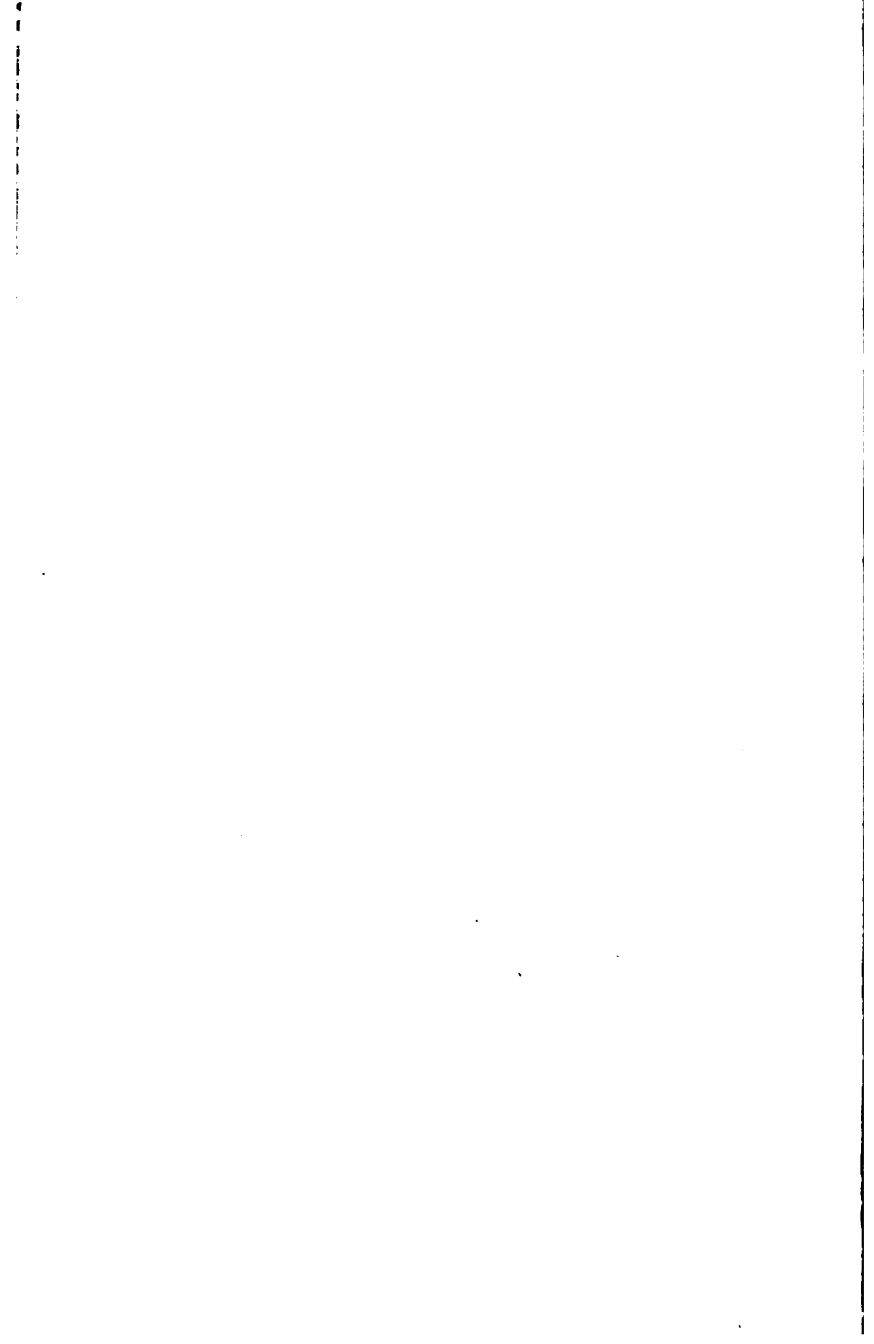
DUPL











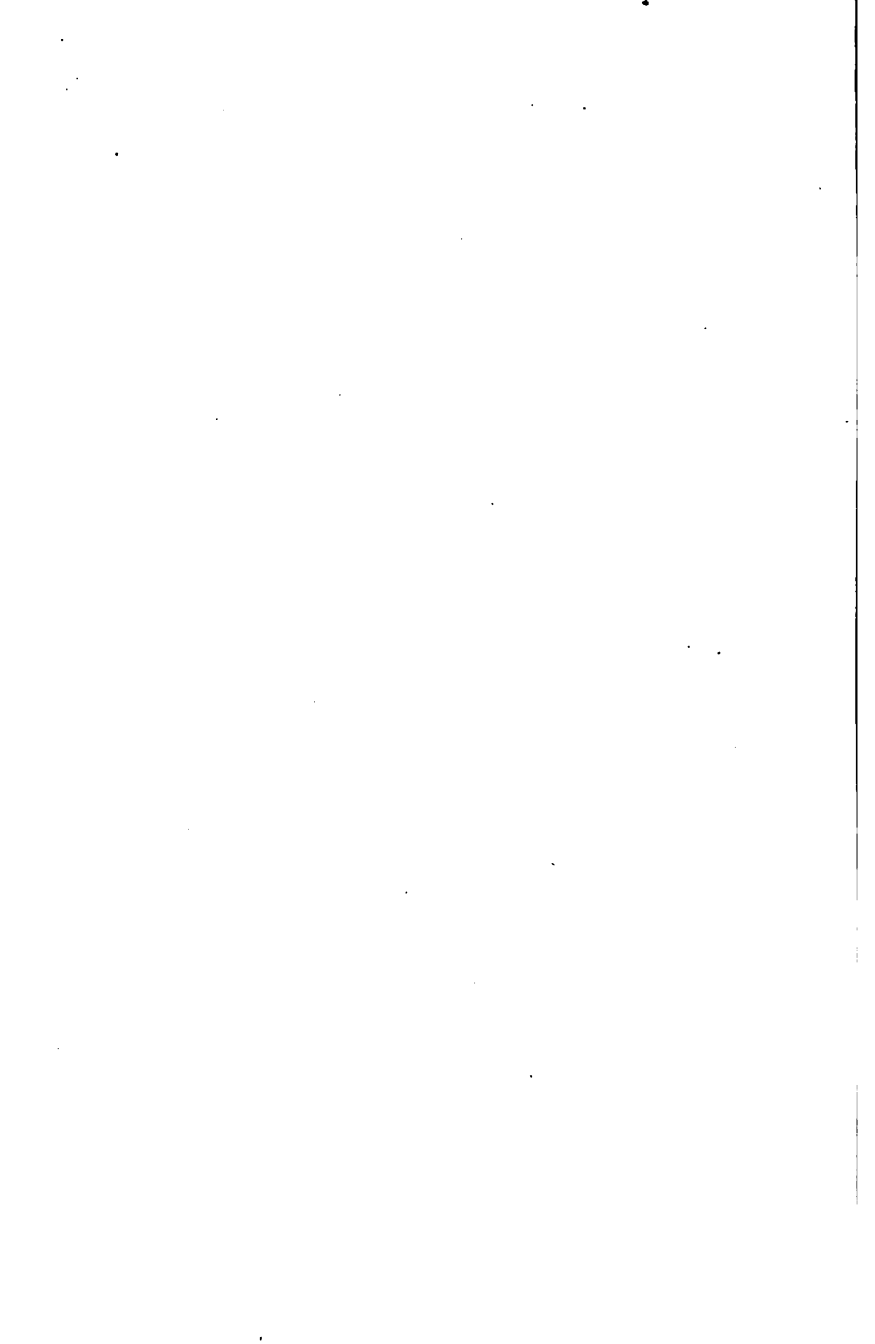
Engin. Library

TJ

603

.S92

1893



Monty Tharp
from
Edin
Christmas 1894.

THE LOCOMOTIVE ENGINE
AND ITS DEVELOPMENT

WORKS BY CLEMENT E. STRETTON, C.E.

SAFE RAILWAY WORKING: A Treatise on Railway Accidents, Their Cause and Prevention. With Illustrations. Third Edition. Thoroughly Revised and much Enlarged. Crown 8vo, 3s. 6d. cloth.

OPINIONS OF THE PRESS.

"The author may be congratulated on having collected, in a very convenient form, much valuable information on the principal questions affecting the safe working of railways."—*Railway Engineer*.

"A book for the engineer, the directors, the managers; and, in short, all who wish for information on railway matters will find a perfect encyclopædia in 'Safe Railway Working.'"—*Railway Review*.

THE LOCOMOTIVE ENGINE AND ITS DEVELOPMENT. Second Edition, Revised and greatly Enlarged. With Illustrations. Crown 8vo, 3s. 6d. cloth.

OPINIONS OF THE PRESS ON THE FIRST EDITION.

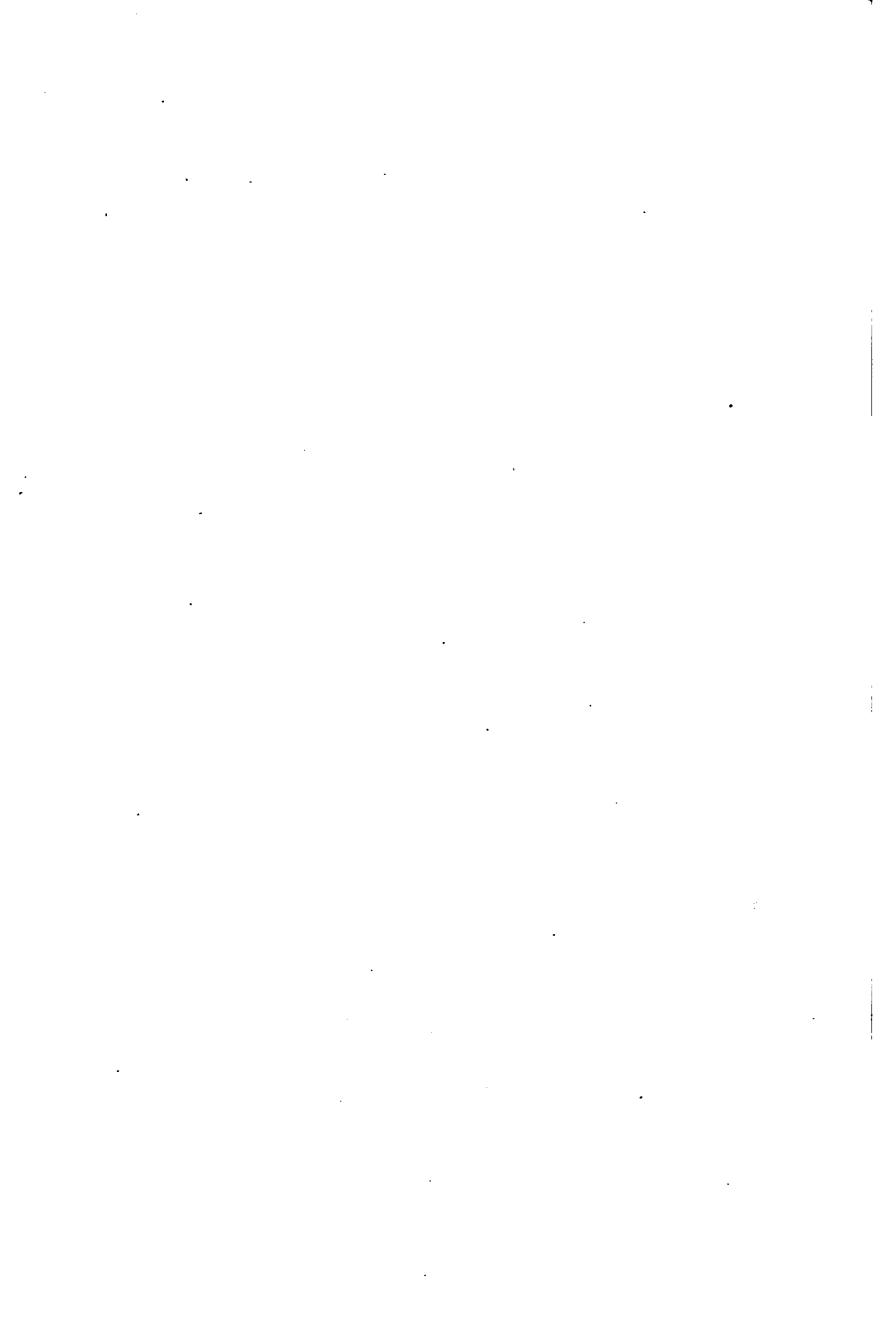
"Students of railway history and all who are interested in the evolution of the modern locomotive will find much to attract and entertain in this volume."—*The Times*.

"The volume cannot fail to be popular, because it contains, in a condensed and readable form, a great deal of just the kind of information that multitudes of people want."—*Engineer*.

"The author of this work is well known to the railway world as one who has long taken a great interest in everything pertaining thereto. No one probably has a better knowledge of the history and development of the locomotive. The volume before us . . . is most interesting, and should be of value to all connected with the railway system of this country."

— *Nature*.

London: CROSBY LOCKWOOD & SON, 7, Stationers' Hall Ct., E.C.





Clement R. Shelton.

THE
LOCOMOTIVE ENGINE
AND ITS DEVELOPMENT

*A POPULAR TREATISE ON
THE GRADUAL IMPROVEMENTS MADE IN
RAILWAY ENGINES BETWEEN*

1803 AND 1893

BY
CLEMENT E. ^{*durin*} STRETTON, C.E.

AUTHOR OF "SAFE RAILWAY WORKING," "NOTES ON RAILWAY BRAKES," ETC., ETC.

WITH NUMEROUS ILLUSTRATIONS

Second Edition, Revised and Enlarged



LONDON
CROSBY LOCKWOOD AND SON
7, STATIONERS' HALL COURT, LUDGATE HILL
1893

Ms. A. 9. 2. 21

DURING the past twenty-two years the Author has given a very large number of lectures and addresses to persons interested in railway engineering, and especially to railway drivers and servants, upon the subject of the Development of the Locomotive; and his articles and communications to the mechanical journals upon the same subject will not be unknown.

In the preparation of those lectures and addresses he has been indebted to many railway companies and locomotive engine builders, who have given him facilities for examining or copying their earlier records, thus enabling him to complete and preserve the histories of several old or forgotten locomotives.

In compliance with resolutions passed at public meetings and with the expressed wishes of many friends, he, in the First Edition of this little book, placed the information thus acquired in a concise and convenient form, giving an outline of the various stages through which the locomotive, as we now have it, has passed.

The very cordial reception which was accorded to the First Edition has been very gratifying, the whole of a large impression having been completely sold out within a few months of publication. The public appreciation of the work, which was thus evidenced, has been reflected also in the very favourable opinions expressed in Engineering and other journals, both in this country and in America; and it may be noted that the only suggestion made has been that subsequent editions should be enlarged and extended.

In accordance with this suggestion, the work has now been carefully revised; some further details have been added with reference to ancient engines; and particulars inserted of the latest designs of engines now being constructed, both in this country and in America; the result being to increase the volume by about fifty pages. A large number of engines, which in the First Edition were simply described, are now clearly illustrated.

The illustrations and descriptions given of such noteworthy engines as the "America" (1829), p. 26; the "Hurricane," p. 76; the "Cornwall" as in 1847, p. 99; and the latest Great Western design, p. 167; will prove especially interesting to all who watch the Locomotive Engine and its Development.

CONTENTS.

	PAGE
INTRODUCTION:—The Early Use of Steam—Steam Carriages intended to run upon Ordinary Roads—Railway Speed . . .	1
CHAPTER I.—EARLY LOCOMOTIVES USED UPON PRIVATE LINES FOR THE CONVEYANCE OF GOODS AND MINERALS:—Trevithick, the Father of the Locomotive—Rack-rails and Cog-wheels—George Stephenson's first Engine—Steam Springs—The Duke of Portland's Tram-road—Engines for the Hetton Colliery	
	5
CHAPTER II.—ENGINES EMPLOYED UPON PUBLIC RAILWAYS FOR THE CONVEYANCE OF PASSENGERS, GOODS, AND MINERALS:—The Stockton and Darlington the first Public Railway. Its Locomotive List—Wilson's Four-cylinder Engine—Hackworth's "Royal George"—The first Locomotive for America—Rainhill Trials—The Liverpool and Manchester Locomotive List—The Leicester and Swannington Locomotive List (<i>facing</i> p. 45)—Ancient Valve-gear—Grasshopper Springs—The first Steam Railway Whistle—A Bogie Engine—The first Six-coupled Goods Engine with inside Cylinders—Mr. Bury's Engines—Four Wheels <i>versus</i> Six—Forrester's Outside Cylinder Engines—Four Eccentrics introduced—Stephenson's "Standard" Passenger Engine—High Foundry Valve-gear	
	19

CHAPTER III.—THE COMMENCEMENT OF THE BATTLE OF THE GAUGES:—	
Ten-feet Driving-wheels a Failure—American Engines in England—McConnell's Tank Engine—Howe's Link Motion—The Long Boiler—Mr. Alexander Allan's Crewe Pattern—Crampton's Patent—A Three-cylinder Engine—The Battle of the Gauges at its height—Eighty-one Miles an Hour—Trevithick's "Cornwall"—Mr. Ramsbottom's Engines—The Narrow Gauge Engines as fast as the Broad—Kirtley's Designs for Midland Railway Engines .	72
CHAPTER IV.—MODERN LOCOMOTIVES FOR MAIN LINE TRAINS:—	
Steam-reversing Gear—Mineral Engines—Various Opinions on Compound Express Engines—Three Cylinders <i>versus</i> Two—Express Engines coupled in front—The latest Great Western Engines	122
CHAPTER V.—GOODS ENGINES HAVING EIGHT COUPLED WHEELS	177
CHAPTER VI.—THE LATEST AMERICAN, AND ENGLISH, DESIGNS .	181
CHAPTER VII.—LIST OF LOCOMOTIVES—RULES FOR GRADIENTS—	
SUNDRY APPLIANCES:— The Steam Sand-blast—A Single Engine the best for Fast Running—Slipping—Adhesion—Invention of the Injector—Giffard's Explanation of its Action—Modern Injectors—Table of Water supplied by various sizes—Valve Gear—Joy's Gear	186

LIST OF ILLUSTRATIONS.

	PAGE		PAGE
The First Locomotive, 1803.	5	Steam Trumpet	52
— "Blenkinsop," 1812	7	The "Experiment," L. & M.	
— "Puffing Billy," 1813	10	Ry. 1833	54
Brunton's Engine, 1813	11	— "Earl of Airlie," 1833	55
Stephenson's First, 1814	12	— "Hercules," 1833	57
Do. Third, 1816	14	— "Patentee," 1834	57
Do. end view	15	— "Atlas," L. & S. Ry.	
Do. "Puffing Billy,"		1834	59
as in 1815	17	— "Liverpool," L. & S.	
The "Locomotion," 1825	20	Ry. 1834	61
— "Experiment," 1826	23	— "Swiftsure," 1834	63
— "Twin Sisters," 1827	24	— "Comet," N. & C. Ry.	
— "Royal George," 1827	24	1835	64
— "Lancashire Witch,"		— "Vulcan," L. & S. Ry.	
1828	25	1835	66
— "America," 1828	26	Stephenson's Standard En-	
— "Agenoria," 1829	29	gine, 1836	67
— "Rocket," 1829	31	The "Atlas," N. & C. Ry.	
— "Novelty," 1829	33	1836	68
— "Invicta," 1830	35	— "Ajax," L. & S. Ry.	
— "Northumbrian," 1830	36	1837	69
— "Planet," 1830	38	Sharp's Engine, 1837	70
— "Mercury," 1830	40	The "North Star," 1837	73
— "Samson," L. & M. Ry.		Grand Junction Railway	
1831	41	Engine, 1838	75
— "George Stephenson,"		The "Hurricane," 1838	76
1831	42	— "Victoria," 1838	78
— "Comet," L. & S. Ry.		— "Hector," 1839	79
1832	44	— "Philadelphia," 1840	81
— "Phoenix," L. & S. Ry.		— "Long Boiler," 1842	85
1832	46	Stephenson's Fork Motion	86
— "Wilberforce," 1832,		Howe's Link Motion	87
<i>facing</i>	47	Mr. Allan's Goods, 1843	91
— "Caledonian," 1832	49	The "Great Western," 1846	95
— "Ironsides," 1832	49	— "Velocipede," 1847	98
— "Samson," L. & S. Ry.		— "Cornwall," 1847, <i>facing</i>	99
1833	50	Do. 1863	99

	PAGE		PAGE
The "Liverpool" (Cramp- ton's), 1848	100	Great Eastern Express . . .	141
— "Jenny Lind," 1849 . . .	103	Manchester, Sheffield, and Lincolnshire Express . . .	145
— "Bloomer," 1850	105	North-Eastern Express . . .	148
— "Problem," 1859	110	London and South-Western Express	150
— "Pacha," 1862	113	Metropolitan District En- gine	157
No. 30 class (Midland), 1864	115	Midland Express	161
" 712 " " " 1869	116	Section showing Gradients of Midland Ry.	163
" 780 " " " 1870	117	Mr. Webb's Latest Com- pound	165
" 800 " " " 1870	119	Mr. Dean's Latest Design . .	167
" 800 tender " " 1870	120	Small Shunting Engine . . .	175
" 890 class " " 1871	121	Large Shunting Engine . . .	176
Glasgow and South-West- ern Express, 1873	122	Arrangement of Sand Blast <i>facing</i>	192
The "Grosvenor," 1874 . . .	124	Details of Sand Blast, <i>facing</i>	192
Midland Mineral, 1875 . . .	126	Details of Injector	195
Brighton Express, 1882 . . .	130	Foot-plate View of Injec- tors	195
Midland Goods	131	Joy's Gear	199
Do. Tender	132	<i>facing</i>	199
Midland Express, 1885 . . .	134	Joy's Gear. Actual Result.	200
Caledonian Express, 1886 . .	136		
Do. Tender	137		
Great Northern Express, 1870-1887	138		

THE LOCOMOTIVE ENGINE AND ITS DEVELOPMENT.

INTRODUCTION.

THE name "locomotive" engine is derived from two Latin words, *locus*, a place, and *motio*, motion; consequently a locomotive is an engine capable of moving itself from place to place.

Great and important improvements in railway and other industries are not the result of the work of one man, but of many minds. Therefore it frequently occurs that the person who works out the details, and brings an improvement to a practical success, is not the first inventor of the crude idea; and it is a matter of regret to both engineers, passengers, and railway servants, that no one book has ever been published giving a full and complete history of the early development of the locomotive engine, showing exactly the part performed by each inventor. The quantity of information which is available is enormous, but it is unfortunately distributed over numbers of books, articles, and papers; and constantly railway companies, even at the present day, discover amongst old documents the drawings and

official details of engines and carriages which for years past have been unknown and forgotten.

Attention should be directed to the fact, that in the early days of railways a very similar set of names was adopted by different lines, for instance a Comet, a Phoenix, a Samson, a Goliath, a Vulcan, an Atlas, a Liverpool were to be found on nearly all lines, and the official lists prove that in 1840 no less than *ten* engines were running in this country named "Liver" and "Liverpool." This shows that those who desire to investigate the history of certain engines must be extremely careful not to be confused by the similarity of names. Another difficulty is that several locomotive makers each built "trial engines" upon their own system or patent, and obtained the permission of certain companies to give them a trial on their lines; in some cases the railway companies afterwards purchased the engines, in others they did not. As an instance of this, Mr. Bury, in 1830, built an engine named "Dreadnought"; it was, by permission, tried on no less than five lines, then taken back to the works, altered or almost rebuilt, a new name, "Liverpool," was put on, and after a trial on two lines it was purchased by an American Railway Company in 1831, but a few months after its arrival it became known as the "Spitfire." The Author happens to have the maker's private number marked upon the drawings which corresponds with that stamped upon parts of the engine itself, or it would have been impossible to trace its history. In a similar way an engine named "John Bull" was sent from Newcastle to the Hudson and Mohawk Railroad in 1831, a year later it was renamed

“Robert Fulton,” and in 1845 it was rebuilt and renamed “Rochester.”

The question of railway speed is one which constantly engages the attention of passengers, and we often *hear* of 90 or 100 miles an hour. During the past twenty-five years the Author has ridden upon many engines, and has travelled in all the fastest trains upon all the railways in this country, for the special purpose of ascertaining their rate of speed. Upon a few occasions, and under favourable circumstances, he has recorded the very high speed of 79·9 miles an hour, but he has never been able to time a train or engine at actually 80 miles an hour.

As long ago as 1853, 81 miles an hour was run by engines upon the Bristol and Exeter Railway, but these have now been altered and their speed reduced. It is not wise to predict what *may* be done in the future, but at present 80 miles an hour is the maximum pace. The *average speed* of the fastest express train, over a long run, without a stop—say 70 or 100 miles—is 54 or 55 miles an hour, and to maintain this it is not necessary to run at more than 70 or 75 miles an hour upon any part of the journey.

As the newspapers often profess to record very extraordinary rates of speed, it may be advisable to point out one possible cause of error. We should beware of “speed indicators” which take their motion from the driving wheels of engines, as the Author, when the train was running no more than 55 miles an hour, has seen an indicator go up to 90 miles an hour, the increase being simply due to the “slipping” of the driving wheels.

The power of steam was known to Hero of Alexandria

about 200 B.C., or fully 2000 years ago, and a book he then wrote treated of the expansive force of steam, and described the cylinder, piston, slide-valve, and common clack-valve.

Although the power of steam was *known*, no attempts appear to have been made to turn it to useful and practical effect, even in stationary engines, until 250 years ago.

In the year 1759, Dr. Robinson suggested to James Watt the idea of steam carriages for running upon common roads, and models were made. Cugnot, in 1769 and 1771, constructed steam carriages. Murdoch, in 1784, followed by many others, also made "models" and "suggestions" for working carriages by steam on ordinary roads; but it was not until the year 1803 that the first tram-road or railway locomotive was constructed. This was built by Richard Trevithick with money provided by his cousin Vivian, and is here illustrated (on the adjoining page), upon a scale of one-eighth of an inch to a foot.

CHAPTER I.

EARLY LOCOMOTIVES USED UPON PRIVATE LINES FOR THE CONVEYANCE OF GOODS AND MINERALS.

TREVITHICK is undoubtedly the “father of the locomotive”; he employed high-pressure steam. He found by experience that flat wheels had sufficient

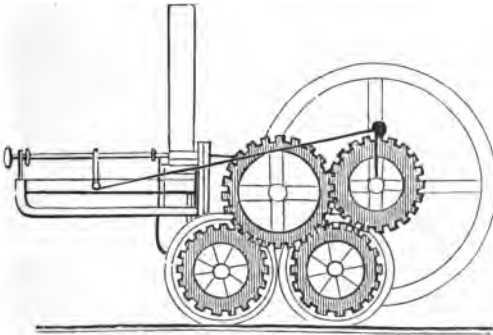


Fig. 1.—The First Locomotive, 1803.

adhesion upon smooth rails, and he conveyed the exhaust steam from the cylinder to the chimney by means of a pipe, which he turned upwards, and dis-

covered, by observing the practical result, that the blast of steam caused the fire to burn much better; he therefore called it the "blast-pipe." This engine ran upon four wheels, 4 feet 6 inches diameter, the boiler was 6 feet in length, and contained a return flue-tube, the chimney being consequently at the same end as the fire-door; the engine had one cylinder placed horizontally, 8 inches diameter, the stroke being no less than 4 feet 6 inches.

On the 24th February, 1804, it was tried upon the Penydarran cast-iron plate-way or tram-road, and conveyed trucks containing ten tons of bar iron and about seventy persons to Merthyr Tydvil, a distance of nine miles. The engine worked satisfactorily from a mechanical point of view, but commercially it was not regarded as a success, being more expensive than horse traction.

Trevithick does not appear to have followed up the development of the locomotive, but left to others the perfecting of those excellent principles which he introduced and discovered; probably it is on this account that he never has received the credit to which he was justly entitled for the construction of the first locomotive which ever ran upon rails.

During the early part of the year 1811, Mr. John Blenkinsop, the proprietor of the Middleton Colliery, near Leeds, decided to convey the coal over his tram-road to that town by means of locomotive engines instead of by horses, and gave an order to Matthew Murray, an engineer, of Leeds, to commence the construction of such an engine. Both Blenkinsop and Murray were under the impression that suffi-

cient adhesion could not be obtained between smooth wheels and smooth rails; and considering the gradients, loads required, and weight of their engine, which was only intended to be five tons, it is probable that their impression was correct. Mr. Blenkinsop, in April, 1811, took out a patent for a rack-rail and cogwheel driving-gear. The engine was completed by Murray, and ran its first trip upon the Middleton line in August, 1812, and at once commenced to convey coal daily from Middleton to the wharf at Great Wilson and Kidacre Streets, Leeds, the distance being about three-and-a-half miles.

The engine was named "Blenkinsop," and ran upon four supporting wheels of 3 feet 6 inches diameter, but they took no part in the driving of the engine. The boiler contained a flue-tube, 20 inches in diameter, having

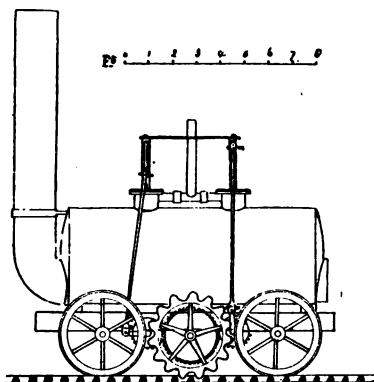


Fig. 2.—"Blenkinsop," 1812.

the fire-grate at one end and the chimney at the other. Two cylinders were employed, 8 in. in diameter, the stroke being 20 inches; the cylinders were placed vertically half within the boiler.

The connecting-rods conveyed motion to cranks, and by means of spur-wheels and gear communicated motion to the main cog or driving-wheel; that wheel

was placed outside the smooth or running part of the rail, and engaged with the outside rack on the rail. Murray placed the two cranks at right angles to each other, thus insuring that one piston was exerting its greatest power when the other was at the end of its stroke. This engine, and others which followed, worked well for many years, and were also a *complete commercial success*. The "Blenkinsop" evaporated eight cubic feet of water per hour, consumed 75 lbs. of coal per hour, and was capable of conveying 94 tons on the level at $3\frac{1}{2}$ miles an hour; its maximum speed being found to be about 10 miles an hour with a gross load of 20 tons.

Messrs. Chapman, in December, 1811, obtained a patent for a method of working the locomotive engine by means of a chain stretched along the whole length of a tram-road, and secured at each end; this chain was in connection with a grooved pulley upon the engine, consequently when this pulley was put in motion, the engine wound itself along the chain; in fact Chapman's chain acted the same purpose as Blenkinsop and Murray's rack-rail. Chapman's system was tried upon the Hetton Colliery tram-road, near Newcastle-on-Tyne, but in a very few weeks proved a complete failure.

Mr. Blackett, of the Wylam Colliery, near Newcastle-on-Tyne, encouraged by the fact that Blenkinsop's engine was a commercial success and conveyed coal at a cheaper rate than horses, decided to make experiments of his own in the same direction. Mr. Blackett and his coal viewer, William Hedley, having made themselves acquainted with the working of the rack-rail system at Leeds, found that to adopt the

Blenkinsop engine would require the Wylam line to be relaid with rack-rails at very great cost. They therefore turned their attention to Trevithick's engine of 1803 (Fig. 1), and ultimately Mr. Blackett remarked, "If Trevithick obtained adhesion with smooth wheels on smooth rails, I can." To test the question, Blackett and Hedley constructed a frame upon four wheels provided with spur-gear and cranks to be worked by hand, and when this apparatus was tried on the Wylam railway, October, 1812, it was found that the smooth wheels gave the necessary adhesion.

Blackett at once gave orders to Hedley to place a boiler upon this frame, and attach connecting-rods to the hand-crank; in fact to turn the test frame into a locomotive. Hedley did so, and the new engine was tried on the Wylam line, February, 1813, but it was short of steam and proved a failure; the reason being that it was not provided with Trevithick's blast-pipe.

In spite of this failure Mr. Blackett had great faith in steam power, and instructed Hedley to pull off all the top part of the engine, and construct a new boiler and cylinders. The engine, as rebuilt, was completed in May, 1813, and tried on the Wylam line. It had a wrought-iron boiler, with a return flue, the chimney being placed at the same end as the fire-door (as in Trevithick's engine); it had two vertical cylinders, the piston-rods being connected to beams, from which motion was communicated to the four smooth driving wheels by means of toothed-gear; the exhaust steam from the cylinders was discharged by two blast-pipes into the chimney, and it was on account of the "puffing" noise caused by these blast-pipes that the engine was named "Puffing Billy." (Fig. 3).



A second engine, similar in every respect to Fig. 3, was at once built, and was named the "Wylam Dilly." Mr. Blackett therefore in 1813 had two locomotives which were successful, so far as conveying coal cheaper than horse-power, but he had by no means arrived at the end of his troubles, as will be seen, page 16.

Mr. Brunton, of the Butterley Ironworks, Derbyshire, obtained a patent, in 1813, for a mode of accomplishing the locomotion of an engine without the aid of the adhesion of the wheels; it was, in fact, a "steam horse," having a pair of hind legs actuated by steam cylinders. It is hardly neces-

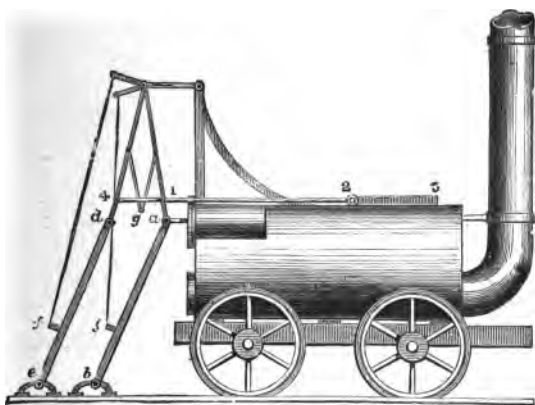


Fig. 4.—"Brunton's Engine," 1813.

sary to say that the arrangement proved a complete failure.

During the time that Blackett and Hedley were engaged at Wylam, Lord Ravensworth and the partners in the Killingworth Colliery, and their engine-wright,

George Stephenson, were anxiously studying the subject at Killingworth. Towards the close of the year 1813 Stephenson designed his first engine, and was at once entrusted by Lord Ravensworth and partners with money to construct a locomotive for their railway. The engine was built at the West Moor workshops of the colliery, and after being under

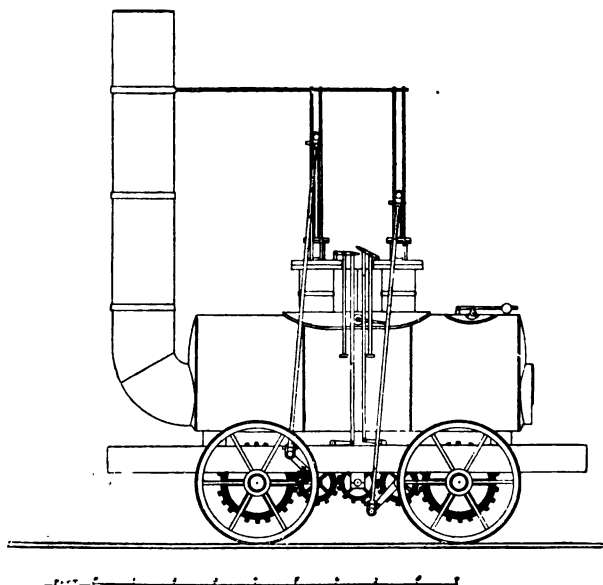


Fig. 5.—George Stephenson's First Engine, 1814.

construction for about ten months, was placed upon the Killingworth railway and tried for the first time on 25th July, 1814, being named or generally known as "Blucher." (Fig. 5.)

This engine ran upon four smooth wheels of 3 feet diameter, placed at a distance of 5 feet apart between

centres. The boiler was 8 feet long, 34 inches diameter, having a flue-tube passing through it, 20 inches diameter. The cylinders were 8 inches diameter, 24 inches stroke, and placed vertically, half within the boiler. The power of the two cylinders was communicated by cross beams and connecting-rods to cranks on the spindles of spur-wheels, which spur-wheels in turn actuated the large cog-wheels on the engine-axles. The small central spur-wheel was employed to maintain the cranks at right angles to each other.

The engine "Blucher," on the 27th of July, 1814, conveyed a train of eight waggons of coal, weighing 30 tons, up a gradient of 1 in 450, at a speed of four miles an hour, and afterwards continued in daily work. This engine was not provided with springs, and the cog-wheel gear becoming worn, Stephenson was entrusted with money to construct a second engine; it was built in 1815, under the protection of a patent granted to Stephenson and Dodd, 28th February, 1815.

In this second engine of Stephenson's the connecting-rods were attached directly to crank-pins upon the wheels, the exhaust steam was discharged into the chimney by two blast-pipes, and the four wheels were coupled together by rods. These coupling-rods, however, were not placed upon the crank-pins outside the wheels, but two double-cranked axles were employed having the cranks at right angles to each other, the two coupling-rods were therefore placed upon these inside cranks, between the wheels. In consequence of one of the crank-axles becoming bent, Stephenson abandoned the arrangement of inside coupling-rods, and

adopted an endless chain passing over a toothed wheel upon each axle.

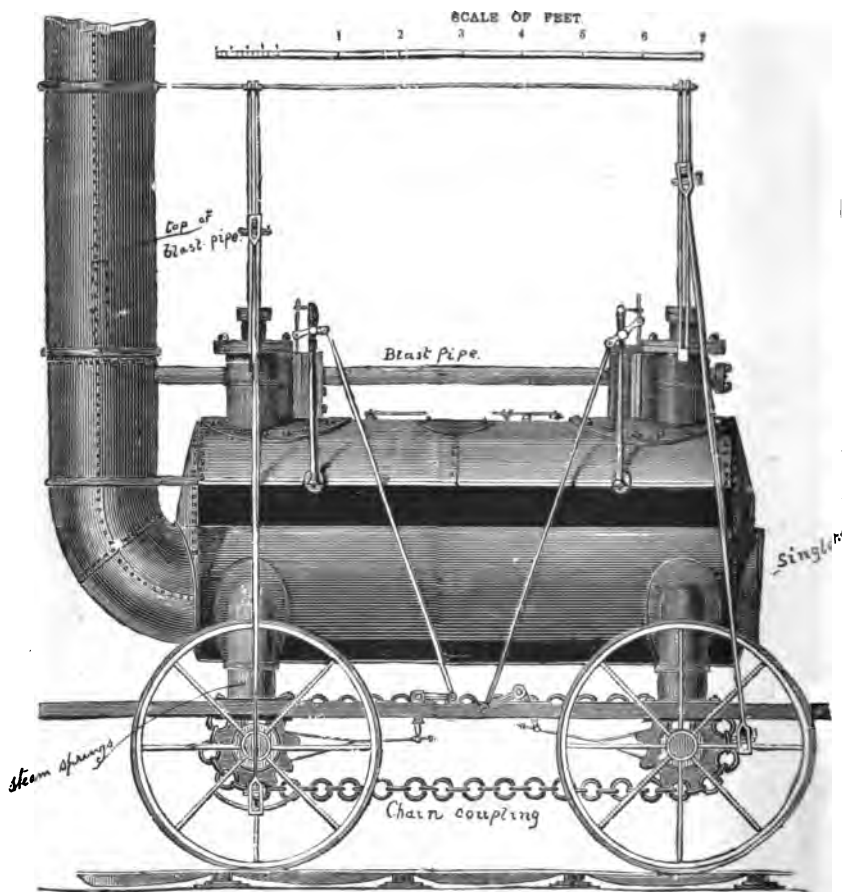


Fig. 6.—George Stephenson's Killingworth Engine, 1816.

George Stephenson constructed for the Killingworth railway a third engine (Figs. 6 and 7), which was

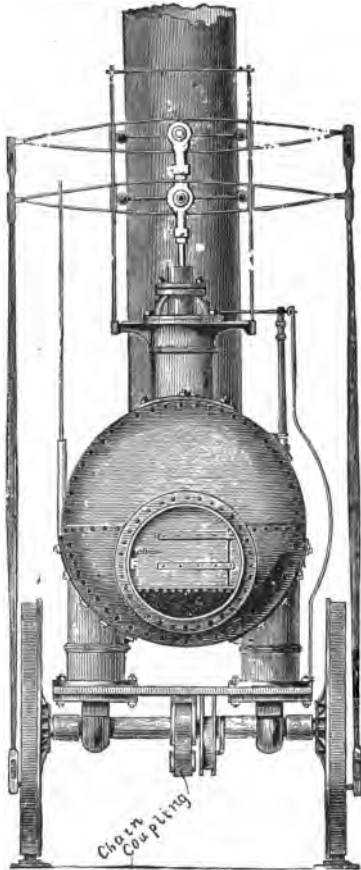


Fig. 7.—End view, Stephenson's Engine, 1816.

provided with steam springs, protected by the Losh and Stephenson patent of September, 1816.

In the illustration (Fig. 6) a portion of the boiler side is supposed to be removed in order to show the single fire-flue. The steam springs, chain system of coupling the wheels, and the blast-pipe are all clearly illustrated.

"Puffing Billy" (Fig. 3) and "Wylam Dilly" rested upon four wheels only, and their weight broke the Wylam cast-iron plate rails to such an extent, that it became necessary to carry half-a-dozen rails upon each engine, to replace those which might break on the journey. The owners of land in the district complained of the noise caused by the blast-pipes, and took counsel's opinion whether the lease of the land for the colliery railway was not vitiated by the noise of the exhaust steam from the chimney frightening the cattle grazing near the line.

To prevent the breaking of the rails Blackett and Hedley placed their engines upon eight wheels, and in order to pass round the curves they put the wheels under two frames; in other words they placed each of their engines upon two *four-wheeled bogies*! and to overcome the blast-pipe difficulty they placed a cylindrical reservoir "S" between the cylinders and the chimney, in order that the steam might escape gradually and without noise by means of the pipe "R."

The first of these engines thus altered, or rebuilt, is here illustrated as it was in 1815 (Fig. 8).

The Wylam railway having been re-laid, the engines were again returned to four-wheeled locomotives in 1830.

"Puffing Billy" remained at work upon the Wylam

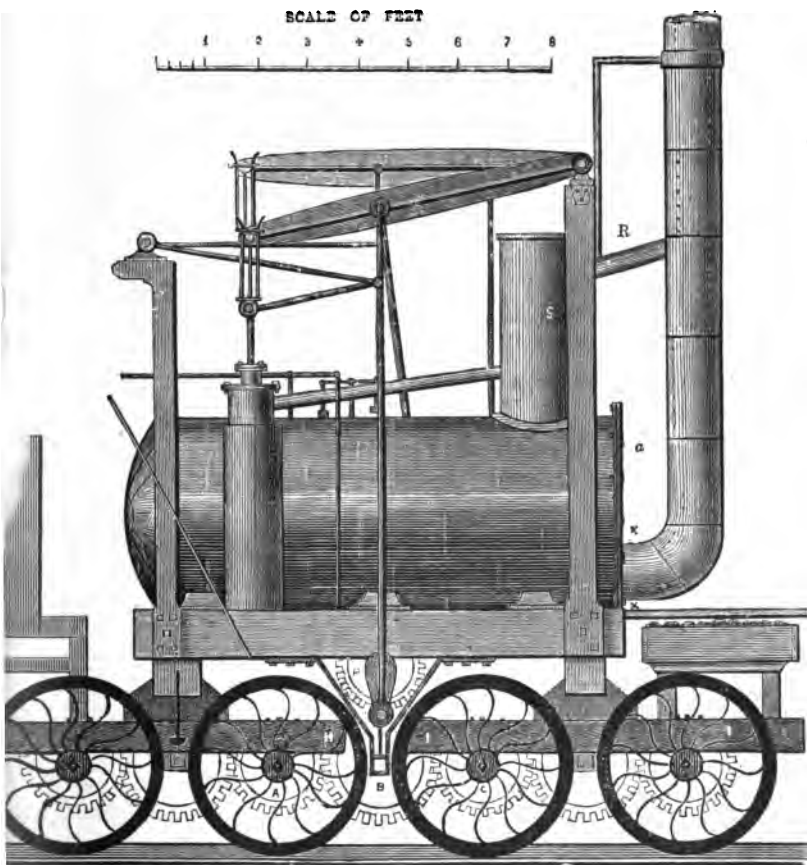


Fig. 8.—"Puffing Billy," as rebuilt 1815.

line till 1862, when it was removed to the South

Kensington Museum; the "Wylam Dilly" is still preserved in the Edinburgh Museum.

The Duke of Portland, in 1817, ordered an engine from George Stephenson, similar in every respect to Fig. 6, for use upon his Kilmarnock and Troon tram-road. The engine worked the coal traffic from the collieries to the Troon harbour successfully, but its use was afterwards given up, as the cast-iron tram-plates proved too weak to carry any engine.

The owners of Hetton Colliery, near Sunderland, having seen the satisfactory working of Stephenson's locomotives upon the Killingworth line, decided, in 1819, to alter their old "horse tram-road" into a locomotive railway, and they employed George Stephenson as engineer, to lay out the line for them, and to construct the engines. At the opening of the Hetton railway on the 18th November, 1822, there were five of Stephenson's engines at work thereon, similar in design to Fig. 6.

CHAPTER II.

ENGINES EMPLOYED UPON PUBLIC RAILWAYS FOR THE CONVEYANCE OF PASSENGERS, GOODS, AND MINERALS.

THUS far, it will be observed, locomotive engines had simply been employed by private colliery owners for conveyance of coal upon their own lines. The Stockton and Darlington "Public Railway" scheme was therefore one of the important turning points in locomotive history. George Stephenson was appointed engineer, and application was made to Parliament in 1818. Twice the bill was rejected, but it passed in 1821, and on Tuesday, 27th September, 1825, this, the first public railway in the world, was opened for traffic. The engine which drew the first train, and, in fact, the only engine the company at that date possessed, was constructed by Messrs. Stephenson & Co., for the Stockton and Darlington line, in 1825, and was named "Locomotion." The handbill issued September, 1825, announcing the intended opening of the first public railway, proudly and emphatically describes "Locomotion" as "The Company's Locomotive Engine and the Engine's Tender."

This engine ran upon four wheels, had one large flue, or tube, through the boiler, the cylinders being placed vertically and half within the boiler; the

exhaust steam from the cylinders was discharged into the chimney by two blast-pipes, one for each cylinder, that one for the left-hand side being plainly shown in Fig. 9. The boiler, which was worked at a pressure of 25 lbs. per square inch, is 10 feet long by 4 feet diameter, and has 60 square feet of heating surface. The two vertical cylinders are 10 inches diameter, and the stroke 24 inches; the piston-rods being guided by parallel motions. By means of a cross-head and

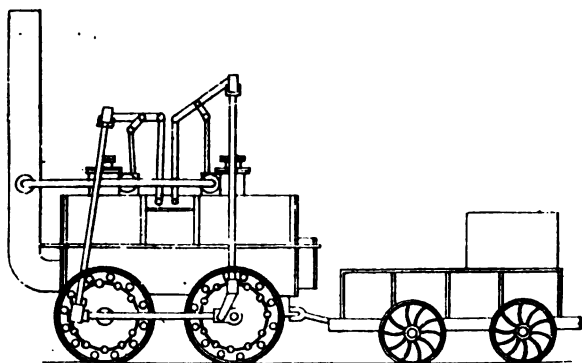


Fig. 9.—Stockton and Darlington Railway. "Locomotion," No. 1, 1825.

pair of connecting-rods the piston of the front cylinder is coupled to the crank-pins upon the leading wheels, the other piston being similarly coupled to the trailing wheels, while outside return cranks on the latter wheels enable the two pairs of wheels to be coupled with the main cranks at right angles. The wheels are 4 feet diameter, and the weight of the engine in working order is 6 tons 10 cwts. It was built at a cost of £600, and its speed was from six to eight miles an hour.

The tender ran upon four wheels of 2 feet 6 inches diameter, the frame being of wood, upon which is mounted a sheet-iron tank holding 240 gallons of water, the coal space being 15 cwts. Weight of tender in working order $2\frac{1}{4}$ tons.

“Locomotion” worked upon the Stockton and Darlington line from 27th September, 1825, to 1841, and after its retirement from active service it was placed upon a pedestal at the entrance to the North Road Station, Darlington, and in April, 1892, it was removed to Bank Top, Darlington. It is still in good working order, and capable of being put in steam. It headed the procession on the opening of the Middlesbrough and Redcar Railway; it was taken from its pedestal and worked upon the Darlington section of the North Eastern Railway, at the Stockton and Darlington Jubilee, September of 1875; it was sent to the Philadelphia Exhibition of 1876, to the “Stephenson Centenary” of 1881, the Liverpool Exhibition of 1886, and it engaged very considerable attention at the Paris Exhibition of 1889.

The following is a copy of the official list of the early Stockton and Darlington locomotives, dated 1833:—

No.	Name of Engine.	Date.	Designed by	Name of Builder.
1	Locomotion....	1825	Stephenson & Co.	Stephenson & Co.
2	Hope	1826	“	“
3	Black Diamond.	“	“	“
4	Diligence.....	“	“	“
5	Royal George*.	1827	T. Hackworth ..	Rebuilt Rlway Co.'s Works, Shildon.
6	Experiment....	1826	Stephenson & Co.	Stephenson & Co.
7	Rocket.....	1829	“	“
8	Victory	“	T. Hackworth...	Railway Co.'s Works, Shildon.

* No. 5 was built by Messrs. Wilson & Co., 1826, and rebuilt by the Company's locomotive foreman, T. Hackworth, October, 1827.

No.	Name of Engine.	Date.	Designed by	Name of Builder.
9	Globe	1830	T. Hackworth ..	Stephenson & Co.
10	Planet	"	Stephenson & Co.	"
11	North Star	"	"	"
12	Majestic	1831	T. Hackworth ..	Railway Co.'s Works, Shildon.
13	Coronation	"	"	Hawthorn & Co.
14	William IV.....	"	"	Railway Co.'s Works, Shildon.
15	Northumbrian..	"	"	Railway Co.'s Works, Shildon.
16	Director	1832	"	Stephenson & Co.
17	Lord Brougham	"	"	Railway Co.'s Works, Shildon.
18	Shildon.....	"	"	Railway Co.'s Works, Shildon.
19	Darlington	"	"	Hawthorn & Co.
20	Adelaide.....	"	"	Stephenson & Co.
21	Earl Grey.....	"	"	Hawthorn & Co.
22	Lord Durham..	"	"	Stephenson & Co.
23	Wilberforce....	"	"	Hawthorn & Co.
24	Magnet.....	"	"	Railway Co.'s Works, Shildon.
25	Enterprise.....	1833	Kitching.....	Kitching.
26	Swift.....	"	Hawthorn & Co..	Hawthorn & Co.

Following the opening of the Stockton and Darlington Railway, Stephenson constructed for it three other engines of similar design to "Locomotion;" they were named "Hope," "Black Diamond," "Diligence;" and Mr. Timothy Hackworth, who had been a foreman at Stephenson's Works, Newcastle, was transferred to the Stockton and Darlington Railway Company's engine-shed at Shildon and became engine superintendent.

During the early part of the year 1826, Messrs. Wilson & Co., of Newcastle, designed and constructed an engine, No. 5, for the Stockton and Darlington Railway, and as that firm considered outside coupling-rods an objection, they placed their engine upon four wheels, and employed four cylinders, two to each pair. Thus the locomotive had two pairs of

independent driving-wheels, a plan more recently used upon the North-Western Railway.

Messrs. Stephenson & Co., early in the year 1826, designed and built “Experiment,” No. 6 (Fig. 10), for the Stockton and Darlington line.

This engine had six coupled wheels, and outside inclined cylinders, 9 inches diameter; stroke 24 inches; wheels 4 feet diameter, boiler 10 feet long by 4 feet diameter. The boiler contained two fire-flue tubes, 18 inches diameter. The exhaust steam was conveyed

from the cylinders to the chimney by two blast-pipes, one for each cylinder.

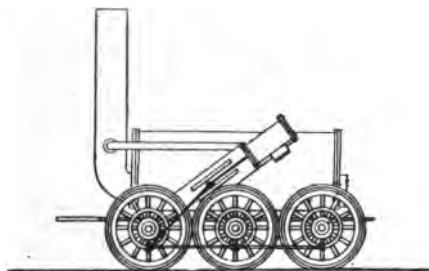


Fig. 10.—Stockton and Darlington, No. 6, 1826.

“Twin Sisters” (Fig. 11) was built by Stephenson & Co., in 1827, as a contrac-

tor’s locomotive at the making of the Liverpool and Manchester Railway, and as it was required to work over very severe temporary gradients it was considered best to construct it with twin boilers, in order to insure that water should at all times cover the tops of the fire-boxes.

This engine ran upon six coupled wheels of 4 feet diameter, the cylinders being placed outside, in an inclined position; two blast-pipes were employed, one for each cylinder. After the completion of the Liverpool and Manchester Railway, “Twin Sisters” became

known as the "Liverpool Coke Engine," from the fact that it was employed to work trains of coke to that city for Mr. Hulton, who contracted to supply the railway company with locomotive fuel.

The four-cylinder engine, No. 5, for the Stockton and Darlington Railway (mentioned on page 22), having worked very unsatisfactorily, and also having been very seriously damaged in a collision at Stock-



Fig. 11.—"Twin Sisters," Ballast Engine, 1827.

ton, Timothy Hackworth, in 1827, obtained the authority of the directors to remodel and rebuild it. The boiler was 13 feet long, and 4 feet diameter, and

into this Hackworth introduced a return flue-tube, similar to those previously employed by Trevithick and by Hedley.



Fig. 12.—"Royal George."
Rebuilt, 1827.

The engine thus rebuilt at the Company's Shildon Works was named the "Royal George," No. 5, and

commenced work October, 1827. (Fig. 12.)

The "Royal George" had six coupled wheels of 4 feet diameter, outside vertical cylinders 11 inches

diameter, the stroke being 20 inches. The fire-door and chimney were both at the same end, consequently two tenders were provided, one at each end of the engine; the exhaust steam was discharged into the chimney by one blast-pipe for both cylinders.

The maximum performance of the "Royal George" was drawing 32 waggons of coal weighing 130 tons at five miles an hour on the level and nine miles an

hour on falling gradients. Weight of engine and its two tenders in working order, 15 tons. The "Royal George" worked regularly upon the Stockton and Darlington line from 1827 to 1842.

Stephenson & Co. in 1828 constructed a four-wheeled coupled engine named the "Lancashire Witch,"

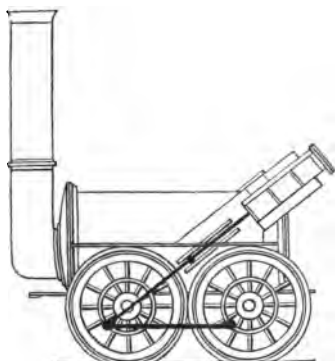


Fig. 13.—"Lancashire Witch," Bolton and Leigh Railway, 1828.

for the Bolton and Leigh Railway. (Fig. 13.)

Cylinders	9 in. diameter.
Stroke	24 in.
Diameter of wheels	4 ft.
Boiler	9 ft. long.
Boiler	4 ft. diameter.
The boiler contained two fire-tubes or flues	1 ft. 6 in. diameter.
Heating surface of flues	66 sq. feet.
Four-wheeled tender.	

The "Lancashire Witch" was employed first as a ballast engine at the construction of the Bolton and Leigh line, and it was found by experiment that this

engine conveyed 58 tons up a gradient of 1 in 432 at

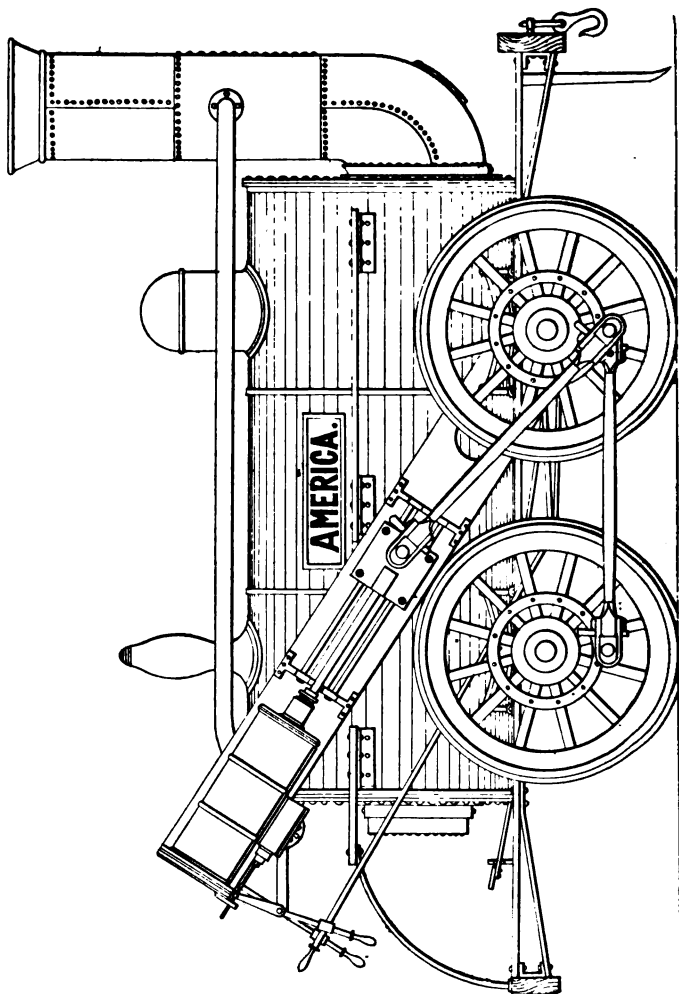


Fig. 14.—The First Locomotive for America, 1828.

a speed of $8\frac{8}{10}$ miles an hour ; it afterwards continued to work traffic for several years.

Early in the year 1828 the Delaware and Hudson Canal Company, having heard of the success of the Stockton and Darlington Railway, sent over Mr. Horatio Allen to England with instructions to obtain information and purchase rails and four locomotives. He gave an order to Messrs. Foster, Rastrick & Co., of Stourbridge, for three, also to Mr. Stephenson for one.

Stephenson's engine was named "America"; it was built in 1828, and arrived in New York, on board the ship "Columbia," about the middle of January, 1829. It was the first railroad locomotive ever seen in America, and is here illustrated. (Fig. 14.)

The following is the copy of the official description of locomotive engine "America," built by R. Stephenson & Co. for the Delaware and Hudson Canal Company, to the order of Mr. Horatio Allen, 1828, and No. 12 in the books of the makers:—

	Ft.	In.
Diameter of boiler	4	1
Length „ „	9	6
Dimensions of fireplace	4ft. 0in.	by 3 0
Diameter of steam cylinders	0	9
Length of stroke	2	0
Size of chimney	1	8
Size of hot-water pump	0	1½
Length of pump stroke	2	0
Wheels (wood) diameter	4	0
Number of wheels 4		
Angle of cylinders to the horizontal 33°		
Size of tubes	1	7
Number of fire tubes 2. Tubes were straight.		

Some persons have contended that the iron-bar-framing in general use in the United States was an American invention, but reference to the illustration, Fig. 14, proves conclusively that the "bar-frame"

was sent from this country. Although Stephenson's engine was the *first* to arrive, it was not the first to be run.

Messrs. Foster & Rastrick's engine, the "Stourbridge Lion" was built 1828, and arrived in New York May, 1829, but neither of the engines for America could be put to work for some months as the railway was not completed. Messrs. Foster & Rastrick's engine, the "Stourbridge Lion," was the first locomotive which ever ran upon rails in America; it was tried for the first time on 9th August, 1829, being driven by Horatio Allen upon a section of the Delaware and Hudson Canal Company's Railroad. The "Stourbridge Lion" was exactly similar to Fig. 15, but with a much shorter chimney. It is still preserved, and was exhibited at the Chicago Railway Exposition of 1884.

Messrs. Foster, Rastrick & Co. in 1829 constructed an engine (Fig. 15) for the Shutt End Railway, which extends from the Earl of Dudley's Colliery at Kingswinford, to the Staffordshire and Worcestershire Canal this locomotive was named "Agenoria," and opened the line on Tuesday, June 2nd, 1829.

This engine has upright cylinders working half beams, thus reducing the stroke of the pistons to the cranks. The cylinders are $7\frac{1}{2}$ inches diameter, with a stroke of 3 feet. There is a parallel motion to the piston-rod, and the feed-pump is worked from one of the half beams. The fire-grate is within a large tubular boiler, branching into two tubes, with the chimney at the end of the boiler, the barrel of the boiler being 10 feet long and 4 feet diameter. The eccentrics for driving the slide-valves are loose upon the axle, with a

clutch to drive either way, and there is hand-gear to the valves to cause the axle to turn half round to bring the required backward or forward clutch into action. The exhaust steam is discharged into the chimney,

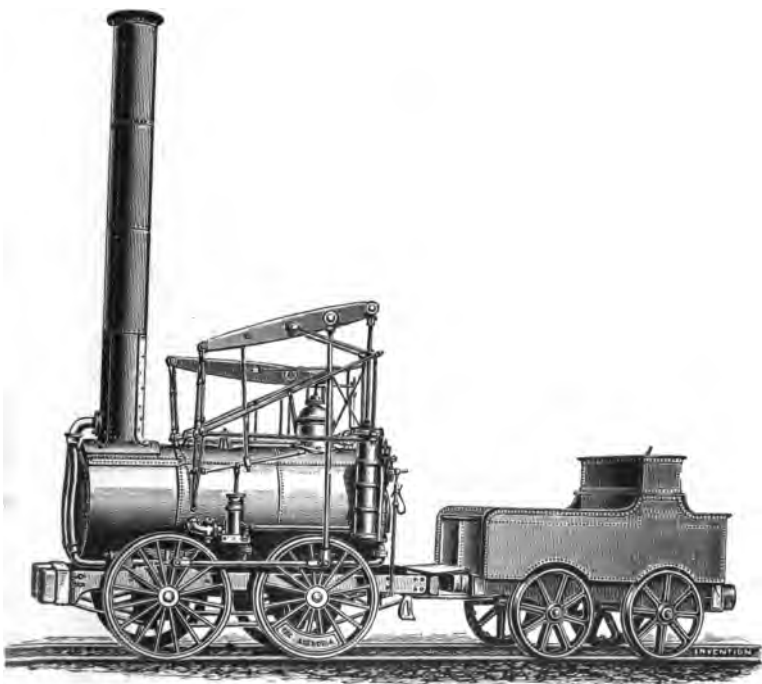


Fig. 15.—“Agenoria,” Shutt End Railway, 1829.

which, it may be mentioned, is of unusual height. “Agenoria” continued in regular work for fully 30 years, and is now preserved in the South Kensington Museum.

The Liverpool and Manchester has been truly

designated "The Grand British Experimental Railway." George Stephenson was appointed engineer, and the line was publicly opened 15th September, 1825.

Some time previously to the opening the question of locomotive or fixed engines and ropes naturally came before the directors, as it was necessary to arrange for "power" to work the traffic; they therefore decided to employ Messrs. Walker and Rastrick, engineers, to make a tour of inspection to examine all the railways then at work; but, notwithstanding the reports, the directors did not feel able to come to a decision, when one of their number, Mr. Harrison, proposed "that a reward be publicly offered for the most likely mode of effecting their object," and it was resolved to offer a prize of £500 for the best engine.

The trial took place on the Manchester side of Rainhill Bridge, upon a level portion of the line, and lasted from the 8th to the 14th October, 1825. Three engines competed for the prize, namely :

The "Rocket"	by G. and R. Stephenson.
The "Novelty"	by Braithwaite & Ericsson.
The "Sanspareil"	by T. Hackworth.

Each locomotive was required to run ten trips over the trial ground, equal to a journey of thirty-five miles, at full speed, the average rate to be not less than ten miles per hour. At the end of the first ten trips each engine was to be got ready again, and to repeat the test, the object being to prove that the engine would be able to perform a journey from Liverpool to Manchester and back.

The "Rocket" (Fig. 16) satisfactorily performed

all the tests required by the judges, and the prize was consequently awarded to Messrs. Stephenson.

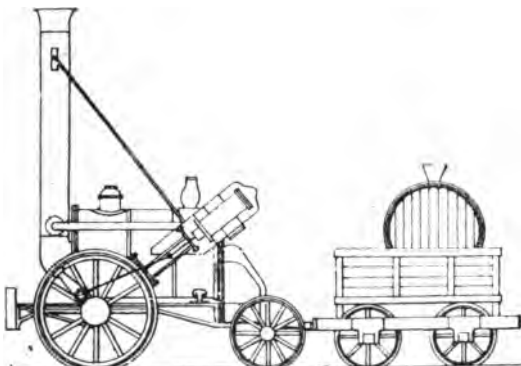


Fig. 16.—“Rocket,” Liverpool and Manchester Railway, 1829.

The dimensions of the “Rocket” were as follows:—

Cylinders, diameter.. . . .	8 in.
Cylinders, stroke	16½ in.
Driving-wheels, diameter	4 ft. 8½ in.
Boiler.. . . .	6 ft. long.
Boiler.. . . .	3 ft. 4 in. diameter.
Pressure of steam in the boiler ..	50 lbs. per sq. inch.
Fire-box	2 ft. long inside.
Fire-box	3 ft. broad inside.
Fire-box	3 ft. deep inside.
Tubes, number	25.
Tubes, diameter	3 in.
Tubes, heating surface	117·75 square feet.
Fire-box, heating surface	20 square feet.
Total	137·75 square feet.
Area of fire-grate	6 square feet.
Weight of engine in working trim	4 tons 5 cwts.
Weight of tender, loaded	3 tons 4 cwts.
Total	7 tons 9 cwts.

The maximum speed attained by the “Rocket” at the Rainhill trials was 29 miles an hour. This engine,

although crude in appearance, possessed all those essential features which are necessary to the success of a locomotive—namely, the tubular boiler, direct connection between the piston and the crank-pin on the driving-wheel, and blast-pipes in the chimney, there being one pipe for each cylinder, as in the engine of 1815, and the “Locomotion” of 1825. It will be observed that so little progress had the locomotive engine made in public favour, that even in the year 1829 the directors of the Liverpool and Manchester Railway were divided in opinion as to fixed engines and ropes, horses and locomotives, and had not the locomotive engine proved itself a success at Rainhill, the result would have been the introduction of other means of working that line. It will therefore be seen that although George Stephenson was not, and of course never claimed to be, the inventor of the locomotive, still he it was who in 1829, at Rainhill, settled the question and made the locomotive a practical success, and thereby led to the introduction of railways throughout the world. It is hardly necessary to mention that the celebrated “Rocket” is preserved in the South Kensington Museum, and it may be added that the “Rocket” and “Sanspareil” have lately been placed upon some of the old original Liverpool and Manchester rails of 1829 which have been presented to that institution by the author for the purpose, and the full-sized models of these engines at the Chicago Exhibition will also stand upon similar old rails.

The “Novelty,” constructed by Messrs. Braithwaite and Ericsson, ran upon four wheels, and had a combined vertical and horizontal boiler; and bellows were employed to force air through the fire. In this engine, motion was communicated from the piston-rod to the

wheels by means of a bell-crank. The "Novelty" broke down and failed at Rainhill.

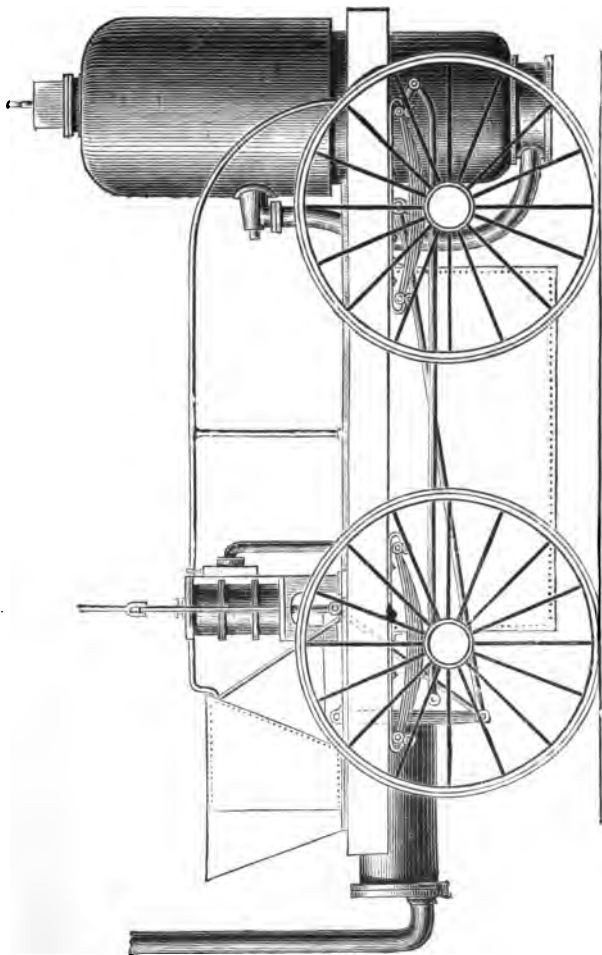


Fig. 17.—The "Novelty," 1829.

The "Sanspareil" was designed and constructed by

Timothy Hackworth, the engine superintendent of the Stockton and Darlington line, for the Rainhill competition. It ran upon four coupled wheels of 4 feet 6 inches diameter. The boiler was 6 feet long, and 4 feet 2 inches diameter, containing a return flue-tube, the chimney being placed at the same end of the engine as the fire-door. The cylinders were 7 inches diameter, and the stroke 18 inches, placed vertically one on each side of the boiler, immediately above one of the pairs of wheels; the exhaust steam from the cylinders was discharged into the chimney by a blast-pipe, similar to that of Trevithick's 1803.

When the "Sanspareil" was brought forward for trial at Rainhill, the judges found that it did not comply with the conditions issued, being of greater weight than was to be allowed to be placed upon four wheels, the engine therefore should have been upon six wheels. Strictly speaking, it was considered that Hackworth's engine was therefore excluded from competing for the prize, but the judges wisely decided to put the engine to the same trial as the others. However, it broke down and failed to obtain the prize. The "Sanspareil" worked upon the Bolton and Leigh Railway until 1844, and is now placed in the South Kensington Museum.

At the conclusion of the Rainhill trials and the victory of the "Rocket," Stephenson received orders to build seven other engines, to be ready for the opening of the Liverpool and Manchester Railway. They were constructed during the year 1830, and were very similar in design to the Rocket; they were named "Meteor," "Comet," "Arrow," "Dart," "Phoenix," "North Star," and "Northumbrian;" they all had outside cylinders and the driving wheels in front.

The Canterbury and Whitstable Railway was opened on the 3rd May, 1830, the first train being worked by the Company's only locomotive, which had been built by Stephenson & Co., and was named "Invicta." (Fig.18.)

Cylinders	10 ins. diameter.
Stroke	18 ins.
Boiler	10 ft. long.
Boiler	3 ft. 4 ins. diam.
Pressure	40 lbs. per square inch.
Wheels	4 ft. diameter.
Wheel-base	5 ft.

The boiler contains a flue-tube 20 inches diam.

The tender ran on four wheels.

This ancient engine is preserved by the South-Eastern Railway Company at its Ashford Works; it was sent to the Darlington Jubilee, 1875, and to the George Stephenson Centenary, 1881.

The Liverpool and Manchester Railway was opened on the 15th September, 1830, upon which occasion the Company's eight engines and trains, and about 600 people, started in a procession from Liverpool in the following order :—

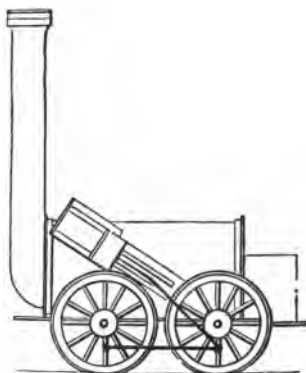


Fig. 18.—"Invicta," Canterbury and Whitstable Railway, 1830.

Name of Engine.	Driven by
"Northumbrian"	George Stephenson.
"Phoenix"	Robert Stephenson.
"North Star"	R. Stephenson, Senr. (brother of George).
"Rocket"	Joseph Locke.
"Dart"	Thomas L. Gooch.

Name of Engine.	Driven by
"Comet"	William Allcard.
"Arrow"	Frederick Swanwick.
"Meteor"	Anthony Harding.

Therefore the engine which opened the Liverpool and Manchester Railway was the "Northumbrian" (Fig. 19).

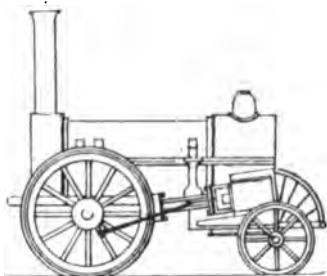


Fig. 19.—"Northumbrian," No. 8,
L. & M. Ry., 1830.

The engine, it will be observed, had a smoke-box, and the cylinders were placed outside, nearly horizontally, the driving-wheels, as in the "Rocket" and six other engines named,

were placed in front. The "Northumbrian" had—

Cylinders	11 ins. diameter.
Stroke	16 ins.
Driving-wheels	5 ft. diameter.
Total heating surface	411·75 sq. ft.
Weight in working order	7 tons 6 cwt. 3 qrs.
Weight on driving wheels	4 tons 1 qr.

On the opening day, when Mr. Huskisson was knocked down and run over at Parkside by the "Rocket," he was conveyed by the "Northumbrian" to Eccles, 15 miles in 25 minutes, or 36 miles an hour. On 16th September, 1830, when the regular traffic of the line commenced, the "Northumbrian" conveyed a train of 130 passengers from Liverpool to Manchester (Liverpool Road Station), a distance of 30 miles, in an hour and fifty minutes.

The following is a copy of the Company's official list of engines to the year 1834:—

No.	Name of Engine.	Date.	Maker.	Diam. of cylinders.	Length of stroke.	Diam. of driving wheels.	Design.	Remarks.
1	Rocket ...	1829	R. Stephenson & Co. ...	Ins. 8	Ins. 16½	Ft. In. 4 8½	"Rocket" class	
2	Meteor ...	1830	"	10	16	5 0	"	4 wheeled engines, outside cylinders, driving wheels in front.
3	Comet ...	"	"	10	16	5 0	"	
4	Arrow ...	"	"	10	16	5 0	"	
5	Dart ...	"	"	10	16	5 0	"	
6	Phoenix ...	"	"	11	16	5 0	"	
7	North Star ...	"	"	11	16	5 0	"	
8	Northumbrian ...	"	"	11	16	5 0	"	
9	Planet ...	"	"	11	16	5 0	"Planet" class	4 wheeled engines, inside cylinders, driving wheels behind
10	Majestic ...	"	"	11	16	5 0	"	
11	Mercury ...	"	"	11	16	5 0	"	
12	Mars ...	"	"	11	16	5 0	"	
13	Samson ...	1831	"	14	16	4 6	"Samson" class	4 wheels coupled.
14	Jupiter ...	"	"	11	16	5 0	"Planet"	
15	Goliath ...	"	"	14	16	4 6	"Samson"	
16	Saturn ...	"	"	11	16	5 0	"Planet" class	4 wheels coupled.
17	Sun ...	"	"	11	16	5 0	"	
18	Venus ...	"	"	11	16	5 0	"	
19	Vulcan ...	"	Fenton, Murray & Co.	11	16	5 0	"	
20	Etna ...	"	R. Stephenson & Co. ...	11	16	5 0	"	
21	Fury ...	"	Fenton, Murray & Co.	11	16	5 0	"	
22	Victory ...	"	R. Stephenson & Co. ...	11	16	5 0	"	
23	Atlas ...	1832	"	12	16	5 0	"Samson"	4 wheels coupled.
24	Vesta ...	"	"	11	16	5 0	"Planet"	
25	Milo ...	"	"	12	16	5 0	"Samson"	4 wheels coupled.
26	Liver ...	"	"	11	16	5 0	"Bury's"	
27	Pluto ...	"	"	12	16	5 0	"Planet"	
28	Caledonian ...	"	R. Stephenson & Co. ...	12	16	5 0	(4 coupled)	Vertical cylinders.
29	Ajex ...	"	Galloway & Co. ...	11	16	5 0	"Planet"	
30	Leeds ...	"	R. Stephenson & Co. ...	11	16	5 0	"	
31	Firefly ...	1833	Fenton, Murray & Co.	11	16	5 0	Roberts' design	Vertical cylinders.
32	Experiment ...	"	Sharp, Roberts & Co. ...	11	16	5 0	(6 wheels)	Inside cylinders.
33	Patentee ...	1834	R. Stephenson & Co.	12	18	5 0	"	"
34	Titan ...	"	Taylor & Co. ...	11	20	5 0	"	"
35	Orion ...	"	"	11	20	5 0	"	"
36	Swiftsure ...	"	Forrester & Co. ...	11	18	5 0	"	Outside cylinders.

Dated 1834, Liverpool.

Towards the close of the year 1829 Stephenson completed the design for a new engine for the Liverpool and Manchester Railway, and it was placed upon that line on the 4th October, 1830.

✱ This engine—the “Planet” (Fig. 20)—was a striking improvement upon all Stephenson’s previous ones. The cylinders were placed “inside” under the smoke-box,

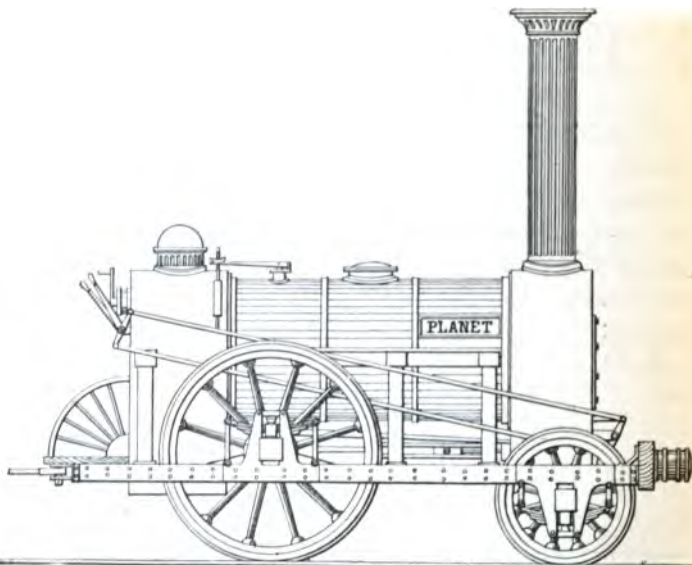


Fig. 20.—“Planet,” No. 9, Liverpool and Manchester Railway, 1830.

the driving-wheels were at the trailing end, and a double-cranked axle was employed, similar to one of those previously used for coupling the engine of 1815. The bar-frame is here abandoned, and an oak-frame employed, plated on both sides with iron: the framing and the axle-boxes were outside the wheels.

Cylinders, 11 ins. diameter; Stroke, 16 ins.; Between centres of cylinders, 2 ft. 6½ ins.; Leading wheels, 3 ft. diameter.; Driving wheels, 5 ft. diameter.

Boiler	6 ft. 6 ins. long.
Boiler	3 ft. diameter.
129 tubes.. .. .	1½ inches.
Heating surface of tubes	370·41 square feet.
" " firebox	37·25 "
Total	407·66 "
Area of fire-grate	6·50 "
Weight in working trim	8 tons 0 cwt. 0 qrs.
On driving wheels.. .. .	5 " 2 " 2 "

This engine had also the usual four-wheeled tender, which weighed 4 tons fully loaded.

On the 23rd November, 1830, the "Planet" worked a special train to convey voters from Manchester to Liverpool for an election; the official report states that "the time of setting out was delayed, rendering it necessary to use extraordinary despatch, in order to convey the voters to Liverpool in time"—the journey was performed in 60 minutes, including a stop of two minutes on the road for water.

On Saturday, 4th December, 1830, the "Planet" drew a mixed train of passengers and goods weighing 76 tons (exclusive of the weight of the engine and tender) from Liverpool to Manchester in 2 hours 54 minutes, including three stoppages of 5 minutes each for water and oiling. This train ran at a rate of $16\frac{1}{2}$ miles an hour down the Sutton incline, and its greatest speed on the level was $15\frac{1}{2}$ miles an hour.

From another official report it is found that between 16th September and 7th December, 1830, the Company's engines conveyed 50,000 passengers, and ran a distance of 28,620 miles, or 954 trips between Liverpool and Manchester and back.

The "Mercury" No. 11 (Fig. 21) was constructed by Stephenson & Co., December, 1830; it was of the

"Planet" type, but with the improvement that the frame was raised so as to be *above* the driving-axle.

Stephenson's "Planet" class of engine, as developed in the "Mercury," became the standard pattern of English four-wheeled locomotives, and was copied in America and other countries shortly afterwards. In December, 1833, a small pair of trailing wheels was added behind the fire-box, and the "Mercury" became a six-wheeled locomotive.

During the year 1830 Mr. Edward Bury, engineer, of

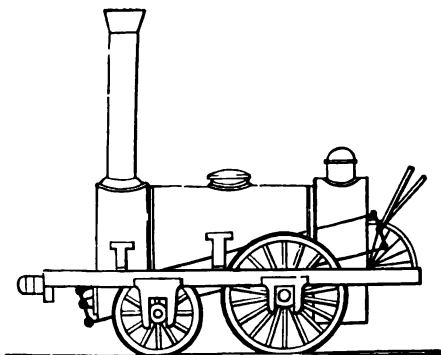


Fig. 21.—"Mercury," No. 11, Liverpool and Manchester Railway, December, 1830.

Liverpool, introduced his afterwards well-known class of four-wheeled engine, in which he employed the bar arrangement of framing, which is in general use to this day in America; and

Timothy Hackworth placed the "Globe" upon the Stockton and Darlington Railway having an inside frame, inside cylinders and four coupled wheels.

For the first few months after the opening of the Liverpool and Manchester Railway, some mixed trains of passengers and goods were run daily, drawn by the "single" engines of the "Rocket" and "Planet" classes; but as the goods traffic gradually increased it

became necessary to work goods trains, and Messrs. R. Stephenson & Co., in January, 1831, placed upon the line two goods engines which "had been specially constructed and were described as of extraordinary power;" they were named "Samson," No. 13 (Fig. 22), and "Goliath" (No. 15).

It will be observed, that practically the "Samson" and "Goliath" were a four-wheeled coupled development of the "Mercury" (Fig. 21), having cylinders 14 inches diameter, 16 inches stroke, and coupled wheels 4 feet 6 inches diameter. Total heating surface 457·10 square feet; weight of engine in working order 10 tons.

The "Samson," on 25th February, 1831, "accomplished the great feat," it is officially

recorded, of conveying a goods train of 164 tons (exclusive of weight of engine and tender), from Liverpool to Manchester in two hours and a half—the maximum speed being 20 miles an hour, and the consumption of coke was reduced to about a third of a pound per ton per mile.

During the time the "Samson" and "Goliath" were under construction, another engine of the same class was built by Stephenson for the Hudson and

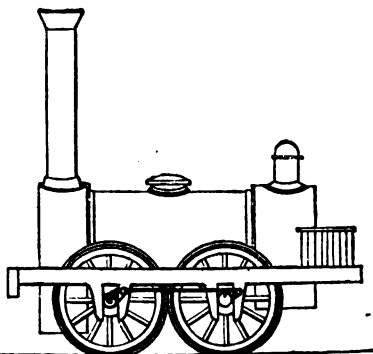


Fig. 22.—"Samson," No. 13, Liverpool and Manchester Railway, January, 1831.

Mohawk Railway, U.S.A., named "John Bull," and it was sent to America in 1831.

The Glasgow and Garnkirk Railway was opened in 1831, the first train being drawn by the Company's engine named "George Stephenson," which had been constructed at Newcastle, and was driven by Mr. George Stephenson upon that occasion.

This engine had cylinders 11 by 16 inches; coupled wheels 4 feet 6 inches diameter; wheel base 4 feet 9 inches. Boiler pressure 50 pounds per square inch.

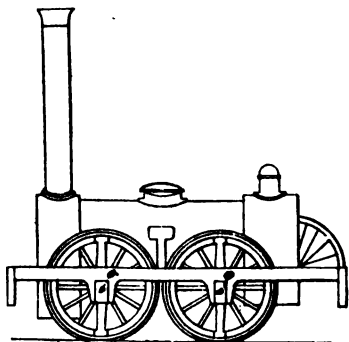


Fig. 23.—"George Stephenson,"
Glasgow and Garnkirk Railway,
1831.

The directors of the Monkland and Kirkin-tilloch Railway (near Glasgow), at the beginning of the year 1831, instructed their engineer, Mr. Dodds, to make out a plan and specification of two locomotive engines, able to drag 60 tons gross weight at the

rate of four or five miles an hour. The engines were built by Messrs. Murdoch and Aitken, Hill Street, Glasgow, the first being tried on the line on May 10th, 1831, and the second on September 10th, 1831. An official report issued to the shareholders stated that the engines were satisfactory.

On January 4th, 1831, the Baltimore and Ohio Railroad Company offered 4,000 dols. premium for the best American locomotive of $3\frac{1}{2}$ tons weight, which should

draw 15 tons at 15 miles an hour on a level. The boiler was to use as fuel anthracite coal ; it was to have four wheels, coupled together, 4 feet between centres, in order to pass around curves of 400 feet radius. The steam pressure was not to exceed 100 lbs. to the square inch above the atmosphere. The locomotives were to be delivered for trial upon the road, on or before June 1st, 1831, and the sum of 3,500 dols. was to be paid for the locomotive which should be adjudged to be best.

Three or four locomotives were entered for competition ; the prize was awarded to Messrs. Davis and Gartner, of York (Pennsylvania), whose engine was named the "York." The locomotive had a vertical-flue boiler and vertical cylinders, with four coupled wheels, 30 inches in diameter. It was altered considerably after being placed on the road.

The same firm afterwards built another locomotive, named the "Atlantic," being the first of what was known as the "Grasshopper" pattern, which was used for many years on the Baltimore and Ohio Railroad, and some of which engines were in use on that road as recently as 1883, and a few continued in service for a period of fifty years.

During the year 1831, the directors of the Leicester and Swannington Railway gave an order to Messrs. R. Stephenson & Co. for two locomotives. The first of these was named "Comet," being No. 4 in the list of the makers, and No. 1 in that of the railway company. It was shipped by sea from Newcastle to Hull, thence by canal to Leicester, where it was put upon the rails and ran its first trip 5th May, 1832, and after doing some preliminary ballasting, it worked the train, upon the opening of the line, from West Bridge, Leicester, to

Bagworth, driven by George Stephenson himself, assisted by his son Robert, and the regular driver Weatherburn.

The cylinders were 12 by 16 inches, the coupled wheels 5 feet diameter, and the wheel-base 5 feet 3 inches; total length of engine frame 16 feet.

The cylinders were placed low down, the piston-rods passing under the leading axle, and the valves were placed upon the tops of the cylinders.

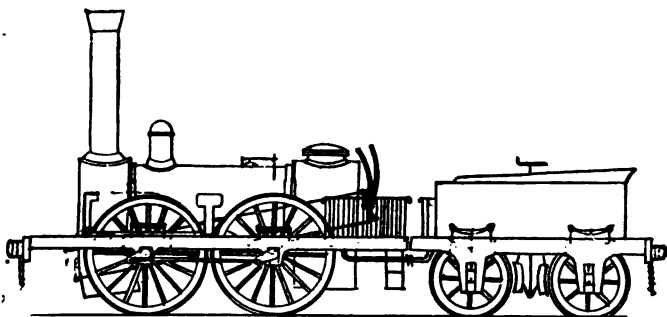


Fig. 24.—“Comet,” No. 1, Leicester and Swannington Railway, May, 1832.

The valve-gear consisted of a single eccentric for each valve, loose upon the driving-axle, motion being communicated by means of studs or “drivers.” These “drivers” were fixed to the crank-axle by collars. When the eccentrics were half-way between the two collars, the axle turned without communicating any movement to them, and the engine was out of gear.

By means of a “treadle” upon the foot-plate, the engineman moved the eccentrics lengthways upon the



[Copy.]

TO ILLUSTRATIONS
VOLUME:—

Fig. 24, p. 44)

Railway Co.'s No.		Name	
4	GOLIATH	R. Steph	
5	HERCULES . .	R. Steph	
6	ATLAS	R. Steph	
7	HERCULES . .	R. Steph	
8	HERCULES . .	R. Steph	
9	HERCULES . .	R. Steph	
10	HERCULES . .	R. Steph	

axle, causing them to engage with either the forward or backward "stud" at pleasure.

The starting or reversing of the engine was accomplished by the engine-driver opening the regulator, and placing his foot upon the "treadle" in order to disengage the eccentrics from the "stud;" another handle enabled him to lift up the small ends of the eccentric-rods, after which he took hold of the two valve levers on the foot-plate, and by moving them backwards and forwards admitted steam to the cylinders by the hand-gear; when the engine was fairly started, he by means of the treadle caused the eccentrics to engage with the opposite "stud" and it continued to actuate the valves; it therefore follows that the handles of the reversing gear upon the foot-plate were constantly moving backwards and forwards during the time the engine was in motion.

The rod of the tender brake passed in a tube through the water tank, and the handle could only be reached by climbing upon the coke.

The chimney of the "Comet," when constructed, was 13 feet in height from the rail level; but it was knocked down in the Glenfield Tunnel on the opening day, and was afterwards reduced to 12 feet 6 inches.

The weight of the "Comet" in working order was 9 tons 9 cwt. 2 qrs., and of the tender fully loaded $3\frac{1}{2}$ tons. In December, 1836, it was sold and sent to be a ballast engine at the making of the London and Birmingham Railway.

Full particulars relating to this engine are given in the annexed copy (see folding plate) of the Company's locomotive list, drawn up by Mr. John Nicholson, the engine superintendent, in 1839.

The second engine built by Messrs. Stephenson for the Leicester and Swannington Railway was the

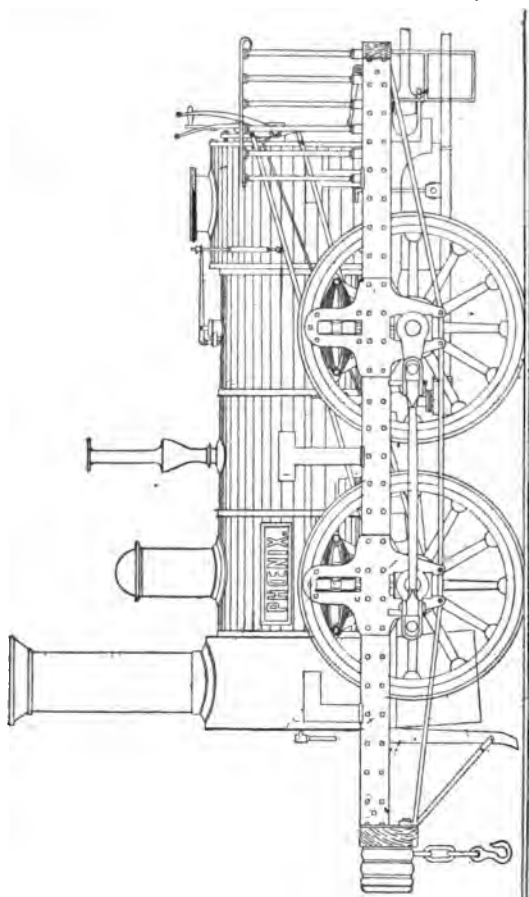


Fig. 25.—“Phoenix,” No. 2, Leicester and Swannington Railway, August, 1832.

“Phoenix,” delivered “in steam” at Leicester, 28th August, 1832.

The springs of “Phoenix” (Fig. 25) were of the Grasshopper pattern : but the experiments made by





Fi

Mr. Cabry, the Company's engine superintendent, showed that they possessed no advantages, and that pattern of spring was therefore not repeated.

In December, 1836, the "Phoenix" was sold and sent to the Birmingham and Gloucester Railway Company, to be used as a ballast engine at the making of that line.

Towards the close of the year 1831, and during the year 1832, several new engines were placed upon the Stockton and Darlington Railway numbered from 12 to 23 (see list, pp. 21, 22). They had boilers with either return-flues or return-tubes, and two tenders. No. 23 is illustrated (Fig. 26).

The "Wilberforce," No. 23, was designed by T. Hackworth, and constructed by Messrs. R. & W. Hawthorn for the Stockton and Darlington Railway, 1832. The chimney and fire-door were both at one end of the engine, the cylinders were placed vertically, and the connecting-rods attached to an intermediate crank. The cylinders were $14\frac{3}{4}$ inches diameter, the stroke 16 inches in length, and the wheels 4 feet diameter. With coal trains the engine burnt about 68lb. of coal per mile. The fire-basket, which did duty for a head or tail lamp, is shown at the back of the water-tender.

Mr. Edward Bury, of Liverpool, who afterwards became head of the well-known firm of Bury, Curtis, and Kennedy, and ultimately the locomotive superintendent of the London and Birmingham Railway was an engineer who took an important part in the early history of the locomotive, and he introduced several features which deserve to be placed on record. Mr. Bury became a locomotive builder shortly after the opening of the Liverpool and Manchester Railway.

He approved of the "bar-framing," of a circular fire-box, with the top of the fire-box casing formed in a large dome, and arranged the tubes in curved rows instead of straight; he also built up the wheels, the spokes being attached by screw bolts to the rim and the boss. Mr. Bury was the leading and most powerful advocate of the four-wheeled engine. He contended that it was less costly than that on six wheels, that it could be got into less space, was lighter and safer, as in his opinion it adapted itself better to the rails. The question of four *versus* six wheels engaged constant attention between the years 1832 and 1854; the competition was extremely severe, but ultimately Mr. Bury's "four-wheeled theory" was proved to be erroneous.

His first engine, named "Dreadnought," was built 1830, it was tried on some English lines experimentally, and in 1831 it was renamed "Liverpool" and went to America to the Petersburg Railroad, where, afterwards, it appears to have been known or renamed "Spitfire."

The Liverpool and Manchester Railway Company's list (see p. 37) shows that in 1832 Mr. Bury built one of his engines, the "Liver," No. 26, for that line, having cylinders 11 by 16 and 5 feet driving-wheels.

Messrs. Galloway, Borman & Glasgow, in 1832, constructed an engine for the Liverpool and Manchester Railway (Fig. 27); it ran upon four wheels of 5 feet diameter, coupled, and as the makers disapproved of the usual "cranked-axle," they placed the cylinders vertically in front of the smoke-box.

The engine was not successful, and after running off the rails upon several occasions, was rebuilt with inside cylinders and a cranked-axle.

Fig. 28 illustrates an old locomotive engine, named "Ironsides," built for the Philadelphia, Germantown, and Norristown Railway Company. It is of interest, being the first railroad locomotive constructed by Mr. Baldwin, the founder of the now famous "Baldwin

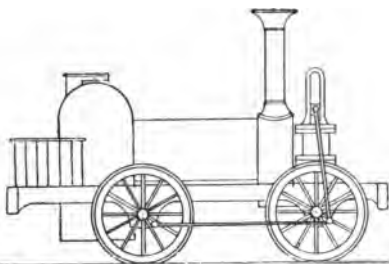


Fig. 27.—"Caledonian," No. 28, Liverpool and Manchester Railway, 1832.

Locomotive Works," Philadelphia, and it was completed and ran a trial trip on November 23rd, 1832.

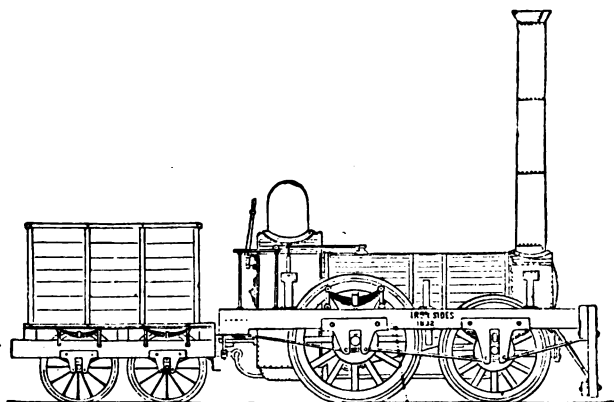


Fig. 28.—"Ironsides," an American Engine, November, 1832.

It will be seen that the "Ironsides" was a four-wheeled engine modelled essentially on the English practice

In August, 1832, Messrs. R. Stephenson & Co. commenced the construction of two locomotives for the Leicester and Swannington Railway. These had cylinders 14 inches diameter, 18 inches stroke, and four coupled wheels of 4 feet 6 inches diameter, the wheel-base being 4 feet 9 inches, and the total length of the frame 17 feet. The first of these engines was named "Samson" (Fig. 29), and commenced work at Leicester, on 1st January, 1833; the other, "Goliath," followed 20th March, 1833.

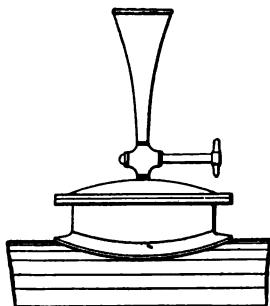
One of the first events in the history of the "Samson" was that it ran into a horse and cart crossing the line at Thornton, the cart being loaded with butter and eggs for the Leicester market. The engine-driver had but the usual "horn," and could not attract attention. Mr. Ashlen Bagster, the manager of the railway, went the same day to Alton Grange to report the circumstance to Mr. George Stephenson, who was one of the directors and the largest shareholder. After various ideas had been considered, Mr. Bagster remarked: "Is it not possible to have a whistle fitted on the engine which steam can blow?" George Stephenson replied, "A very good thought, go and have one made," and such an appliance was at once constructed by a local musical instrument maker. It was put on in ten days, and tried in the presence of the board of directors, who ordered other trumpets to be made for the other engines which the company possessed. The following illustration (Fig. 30) is a copy of the official drawing.

The accident at Thornton was therefore the origin of the steam whistle, and the bell whistle, as we now have it, is an improvement upon the trumpet. When new

the "Samson" and "Goliath" had iron fire-boxes and copper tubes. These tubes were found to wear out very quickly, and the author has read correspondence addressed by Mr. Cabry to the makers, showing that within four months copper tubes were bursting and delaying the trains, and during the

[COPY.]

"LEICESTER AND SWANNINGTON RAILWAY.



Height, 1 ft. 6 in. ; diam. of top, 6 in.

Engine Superintendent's Office, Leicester.

(Signed) HENRY CABRY.

May, 1833."

Fig. 30.—The Steam Trumpet.

summer of 1833 brass tubes were substituted in these engines.

During the year 1833 the portion of the Leicester and Swannington Railway extending from the top of the Swannington to the top of the Bagworth incline was opened by the "Samson" (Fig. 29), driven upon the occasion by Mr. Robert Stephenson.

It was very soon found in practice that the "Samson" and its fellow engine "Goliath," having a long frame

and short wheel base, caused considerable oscillation and threatened serious damage to the permanent way. It was therefore decided by the directors, acting upon the advice of one of their number, Mr. George Stephenson, to have a small pair of trailing wheels added behind the fire-box in the position shown on the diagram. The necessary pairs of wheels and axle-boxes were sent from Newcastle to Leicester, where they were attached by the company's fitters, under the direction of Mr. Cabry, engine superintendent.

Thus the Swannington Company's "Samson" and "Goliath," in the early part of the year 1833, became the first inside cylinder goods engines upon six wheels. The flanges were also taken off the middle or driving-wheels. The change from four to six wheels increased the wheel base to 9 feet 1 inch, and proved so satisfactory that Mr. George Stephenson, after riding upon the "Samson," decided never to build another four-wheeled engine, and he at once took steps to add similar pairs of wheels to the goods engines he had constructed for the Liverpool and Manchester Railway.

The South Carolina Railroad Company ordered an engine from Messrs. Stephenson, and it was placed on that line in 1833, named "Edgefield" and No. 54 in the books and records of the makers. It had cylinders 10 inches by 16 inches and four coupled wheels of 4 feet 6 inches diameter, its weight in working order being only 6 tons 4 cwts. Some writers have expressed surprise that such a small engine should have been built *after* others of larger dimensions. It is therefore necessary to record the fact that the rails were not suitable to carry an engine of either greater weight or longer wheel-base. Another engine built

by the same makers in 1833, for the Hudson and Mohawk Railroad Company, was named "Brother Jonathan;" it was also limited in size and weight.

Messrs. R. Stephenson & Co., in 1833, constructed an engine for the Saratoga and Schenectady Railroad of America; it had a leading bogie, and a single pair of driving-wheels placed behind the fire-box. The "bogie" was found to work very satisfactorily upon sharp curves, and has always been in use upon American passenger engines.

Mr. Roberts—of the firm of Messrs. Sharp, Roberts & Co., now Sharp, Stewart & Co.—in the year 1833 designed and constructed an engine for the Liverpool and Manchester Railway (Fig. 31).

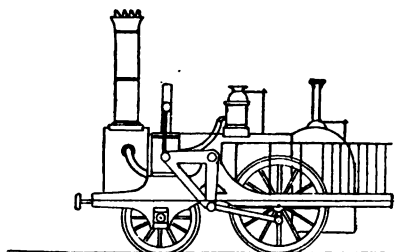


Fig. 31.—"Experiment," No. 32, Liverpool and Manchester Railway, 1833.

The cylinders were placed vertically over the leading wheels, the motion of the cross-heads being communicated to the crank-pins upon the driving-wheels by means of connecting-rods and bell-cranks. The leading wheels had outside, and the driving-wheels inside bearings; the cylinders were 11 inches diameter, the stroke 16 inches, and the driving-wheels 5 feet diameter.

This engine had no eccentrics to actuate the valves, short lever on the bell-crank giving the throw by an

long rod to rocking gear on the foot-plate. The valves were tubular, without lap or lead. The pistons had not the usual elastic packing rings, but were made nearly frictionless by exactly fitting the vertical cylinders, and having a white metal surface.

This engine was very unsteady when running, and

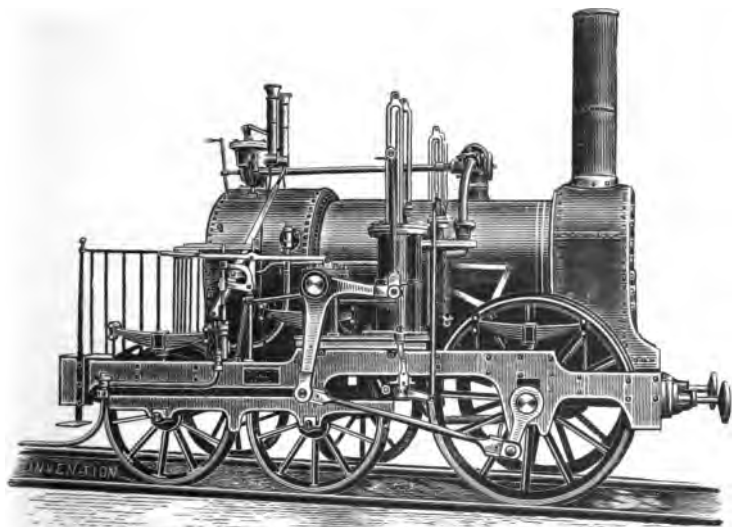


Fig. 32.—“The Earl of Airlie,” No. 1, Dundee and Newtyle Railway, 1833.

after running off the line it was rebuilt with the position of the cylinder and bell-crank altered, and another pair of wheels was afterwards added, but it proved a complete failure.

Fig. 32 illustrates an interesting link in locomotive history, showing as it does one of the first engines

having a "bogie" ever used on a railway in this country.

This engine was built by Messrs. Carmichael & Co., of Dundee, and commenced work upon the Dundee and Newtyle Railway, September, 1833, and during the same month "The Lord Wharncliffe," No. 2, was completed; followed by "The Trotter," No. 3, in March, 1834.

These three engines were in every respect similar, and had a single pair of driving-wheels 4 feet 6 inches in diameter, placed in front, and a four-wheeled bogie, the cylinders being vertical, 11 inches in diameter, and the stroke 18 inches. Weight of engine, in working order, without tender, 9 tons 10 cwts.; cost of engine, without tender, £700. Gauge of railway, 4 feet 6 inches.

The "Earl of Airlie" worked satisfactorily until 1850, when it was employed to pump water as a stationary engine. In 1854, Mr. Allan, when locomotive superintendent of the Scottish Central, had it properly cleaned, painted, and photographed, and it is from this photograph that Fig. 32 is produced.

Messrs. R. Stephenson & Co. delivered the "Hercules" to the Leicester and Swannington Railway Company, 17th December, 1833, being No. 36 in the books of the makers, and No. 5 in those of the Company (Fig. 33); it had copper-fire-box and brass tubes.

The cylinders were 14 inches by 18 inches, the working pressure of steam being 55lbs. per square inch, which was afterwards increased to 60lbs. When built, this engine had a flange upon the driving-wheels; this was, however, removed after it had been at work about three months.

Experience having proved that six-wheeled goods

engines were superior to four-wheeled, Messrs. Stephenson determined to apply the same principle to

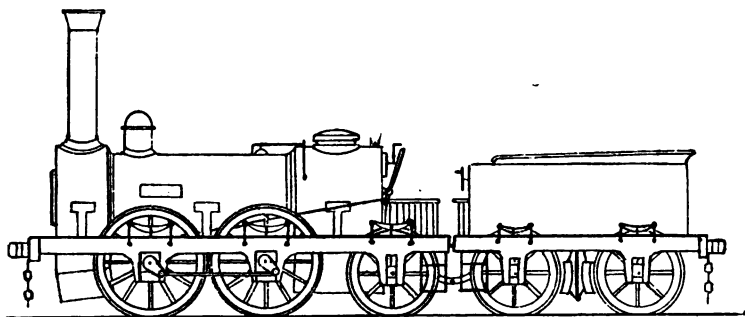


Fig. 33.—"Hercules," Leicester and Swannington, Dec., 1833.

passenger engines, and constructed the "Patentee" for the Liverpool and Manchester Railway, upon the model of the "Mercury" (Fig. 21), but with an addi-

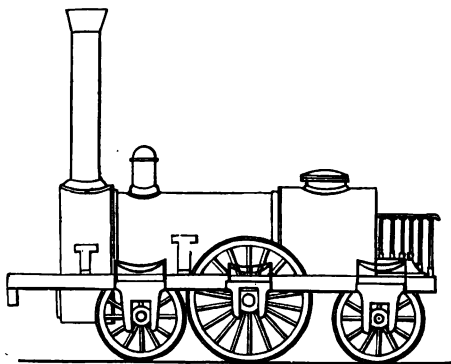


Fig. 34.—"Patentee," No. 33, Liverpool and Manchester Railway, January, 1834.

tional small pair of trailing wheels under the foot-plate. This engine (Fig. 34) was named "Patentee,"

on account of its being the first constructed by Stephenson under his patent of 1833, which provided that six-wheeled engines should have no flanges upon the middle pair of wheels, in order that they could easily pass round curves.

The cylinders were 12 inches by 18 inches, and the driving-wheels 5 feet diameter.

Special attention should be directed to this engine, which became a standard pattern, and was very extensively copied in this country and all parts of the world, and many of the modern passenger engines are "developments" of the "Patentee."

The large increase in the coal traffic upon the Leicester and Swannington Railway necessitated the use of more powerful engines to convey the trains over the rising gradients between the top of the Swannington incline and the top of the Bagworth incline. To overcome the difficulty, Mr. Stephenson decided to construct a new engine, having six coupled wheels; it was delivered at Leicester 8th February, 1834 (Fig. 35).

The "Atlas" had cylinders 16 inches by 20 inches, and weighed 17 tons, in working order, without the tender; it was, therefore, when built, the largest, heaviest, and most powerful locomotive running; its working was therefore watched with considerable interest, as shown by the reports which had to be sent weekly to the directors, and to the makers, for several months, and the copies we have seen in the railway company's books show that the "Atlas" was "highly satisfactory." It was stationed at the Long Lane, now Coalville, and worked for fully 25 years, becoming the property of the Midland Railway Company when the Swannington line was purchased. This engine was

afterwards let on hire to colliery owners, and was ultimately sold to a contractor, being finally broken up after working for more than 40 years.

It was the first goods engine ever built combining the six coupled wheels and inside cylinders—a pattern since very generally employed. The boiler was flush-topped, clothed with polished oak strips, bound round with brass hoops; a steam-trumpet was provided. The

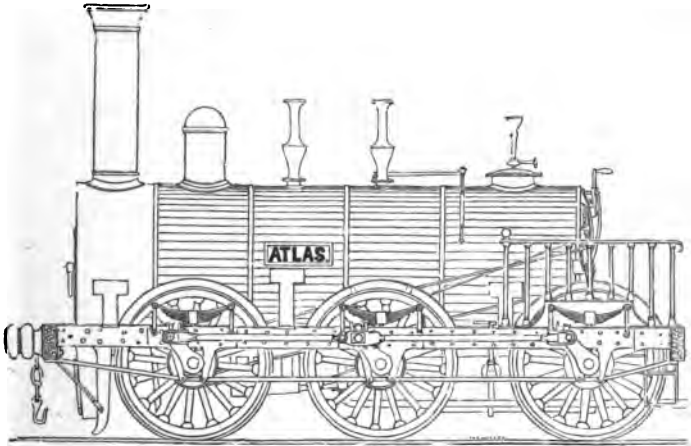


Fig. 35.—"Atlas," Leicester and Swannington Railway, Feb. 1831.

wheels were 4 feet 6 inches diameter, the driving-wheels without flanges. A long and most complete series of experiments was carried out by Mr. Henry Cabry, the company's engine superintendent, to ascertain exactly its performance, the result being that several other engines of similar design were built for other railways.

The Leicester and Swannington list (see page 45) shows that the first six engines for that line were built by Stephenson & Co. However, in 1833 some of the

directors desired to give a trial to Bury, Tayleur and the Haigh Foundry Company, but Mr. Stephenson being a director, they appear to have felt anxious to know the opinion of their colleague. It was, therefore, decided to write a private note on the subject, to which George Stephenson wrote the well-known reply:—
“Very well; I have no objection, but put them to this fair test; hang one of Bury’s engines on to one of mine, back to back; then let them go at it, and whichever walks away with the other, that’s the engine.”

The order was given to Mr. Bury in 1833, who personally assured the directors that “whatever Stephenson’s engine could do his could do,” and an engine named the “Liverpool” was placed upon the line during the year 1834 (Fig. 36).

The “Liverpool” (Fig. 36) ran upon four wheels, 4 feet 6 inches diameter, the cylinders being 12 inches diameter, and the stroke 20 inches. Weight of engine in working order 10 tons, weight of tender loaded 4 tons 10 cwt.

A peculiar feature in this engine was that the two eccentrics were placed upon the leading axle, and the eccentric rods passed in two spaces or boxes through the smoke-box to the valve-levers placed behind the buffer beam; it therefore followed that the admission of steam to the cylinders for working the driving-wheels was dependent upon the movement of the leading wheels and coupling-rods; consequently any failure of crank-pins or coupling-rods rendered the engine useless, and the books of the company recorded two or three such failures.

The engine was reversed by means of four handles, two to work the valves by hand, one gab-handle to

throw the small ends of the eccentric-rods into or out of gear, and one to move the two eccentrics.

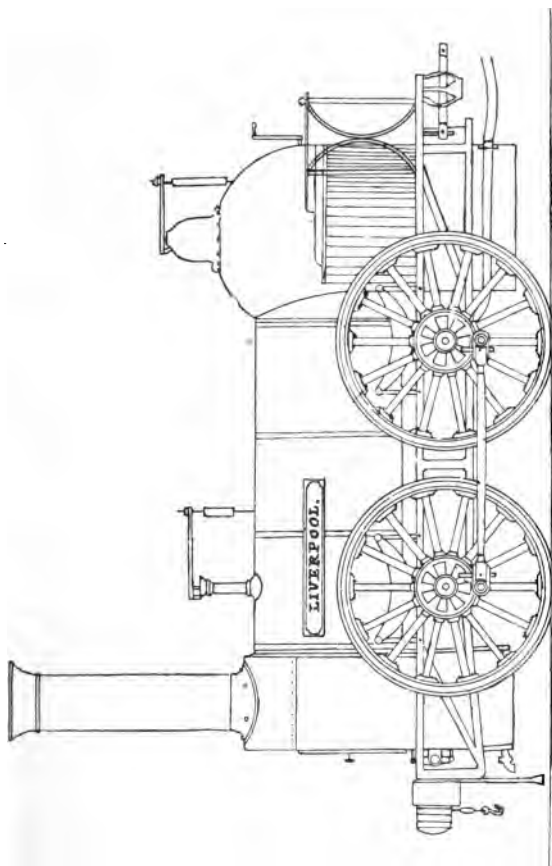


Fig. 36.—"Liverpool," No. 7, Leicester and Swannington Railway, 1834.

A series of practical trials were made with a train of waggons upon the Swannington Railway in the

presence of the directors, when Mr. Bury was ultimately obliged to admit that his engine (Fig. 36) was not equal to taking the trains conveyed by Stephenson's "Atlas" (Fig. 35).

In 1834, Messrs. Sharp, Roberts & Co. supplied three engines exactly similar to the "Experiment" (see Fig. 31), for the opening of the Dublin and Kingstown Railway, named "Hibernia," "Manchester," and "Britannia."

None of these engines were found satisfactory, and the firm abandoned the "bell-crank" design.

Mr. George Forrester opened the Vauxhall foundry at Liverpool in 1834, the first locomotive constructed by the firm being the "Swiftsure" (Fig. 37).

This engine was the first ever constructed combining *outside* horizontal cylinders and six wheels. The connecting-rod, it will be observed, worked upon an outside crank. The "Swiftsure" also was the first locomotive ever built with *four* eccentrics.

This valve gear was Forrester's patent, in which each of the four eccentrics was furnished with a fork or "gab-end," and placed vertically, as shown (Fig. 37.)

The chief dimensions of the "Swiftsure" were cylinders 11 by 18, driving-wheels 5 feet diameter, total length of frame 17 feet.

In consequence of the extreme distance apart of the cylinders, 7 feet 1 inch, and the unbalanced driving-wheels, this and other similar engines oscillated to a very serious and dangerous extent at even moderate speed. They were generally known as "Boxers," and proved a practical failure, as they could not be allowed to exert their full power or speed, as they either left the line or burst the rails.

During the year 1834 Messrs. Forrester built three four-wheeled engines for the Dublin and Kingstown

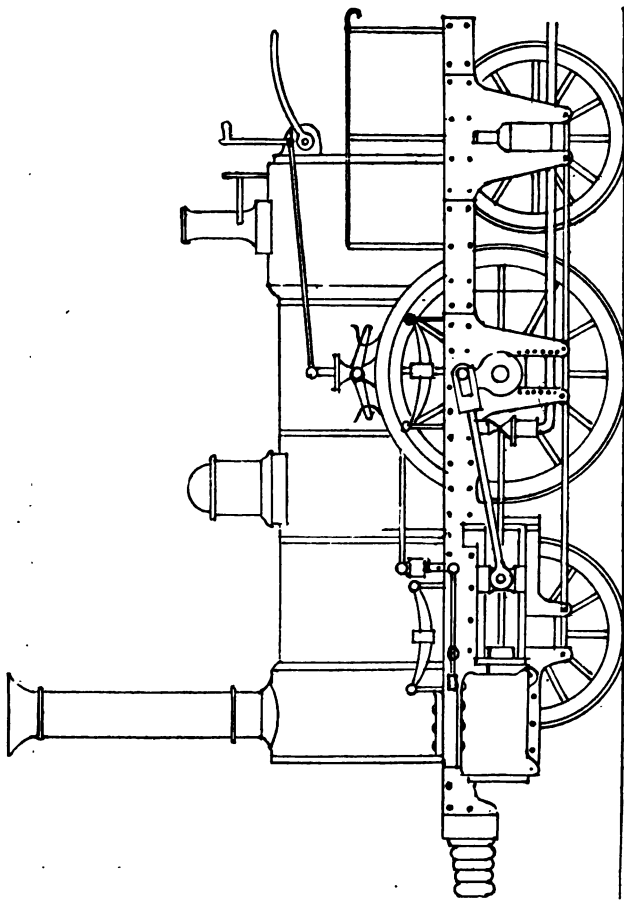


Fig. 37.—“Swiftsure,” No. 36, Liverpool and Manchester Railway, 1834.

Railway named “Dublin,” “Kingstown,” and “Vauxhall;” like the “Swiftsure,” they were very unsteady.

Messrs. R. & W. Hawthorn & Co., of Newcastle, designed and constructed in 1835 an engine for the Newcastle and Carlisle Railway (Fig. 38).

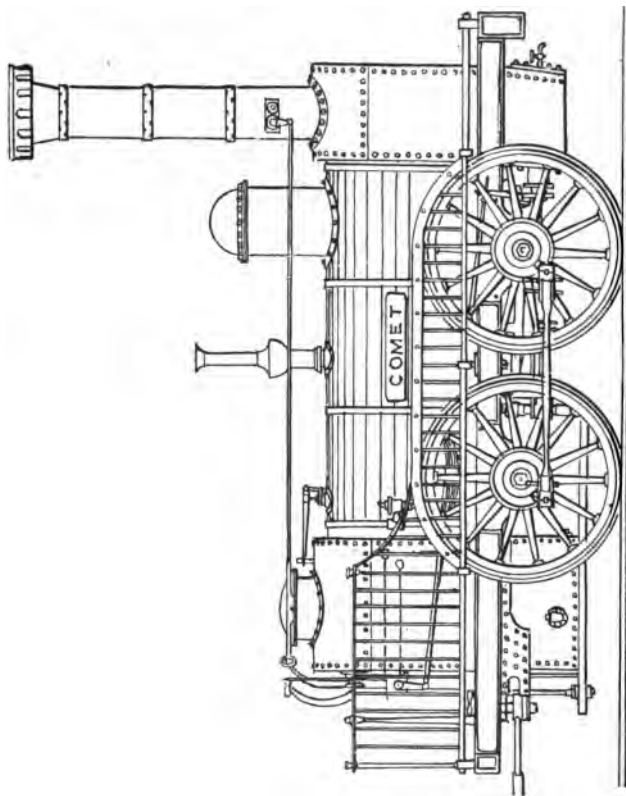


Fig. 38.—“Comet,” No. 1, Newcastle and Carlisle Railway, 1835.

The “Comet” (Fig. 38) conveyed one of the trains of passengers at the opening of the first section of the Newcastle and Carlisle Railway, March 9, 1835. It had four coupled wheels 4 feet diameter, the cylinders

were 12 inches diameter, and the stroke 16 inches; it will be seen that they were placed low down under the smoke-box, the piston-rod working under the leading axle. The valves of the "Comet" were actuated by Hawthorn's gear.

Heating surface of fire-box	35 square feet.
Heating surface of tubes	237 square feet,
Total	272

Pressure of steam 60 lbs. per square inch. The tender ran upon four wheels and carried 680 gallons of water.

The "Comet" and several other engines of a similar design worked with great efficiency for many years upon the Newcastle and Carlisle Railway.

Another powerful locomotive being required for the Leicester and Swannington Railway, an order was given to Messrs. Tayleur & Co., of the Vulcan Foundry, near Warrington. The engine (Fig. 39) was delivered "in steam," at the West Bridge Station, Leicester, on the 2nd April, 1835. It had cylinders 16 by 20, and six coupled wheels of 4 feet 6 inches diameter, and was a very similar type to the "Atlas" (Fig. 35). The valve gear was of the loose eccentric type, described pages 44 and 45.

During the early part of the year 1836, Messrs. Tayleur & Co. completed the "Star" for the Liverpool and Manchester Railway, being the first of an order of ten "short-stroked" passenger engines. The cylinders were 14 inches diameter, only 12 inches stroke, the driving-wheels being 5 feet diameter. It was found in practice that the "short stroke" was not an advantage.

Messrs. R. Stephenson & Co. in 1836 constructed

several passenger engines upon a similar design to the "Patentee" (Fig. 34), but of larger size, one of which is shown in section (Fig. 40).

It will be observed (Fig. 40) that the steam dome was placed upon the fire-box casing, also that the engine had four fixed eccentrics, and forked-ends to the eccentric-rods; the two "forward" or two "back-

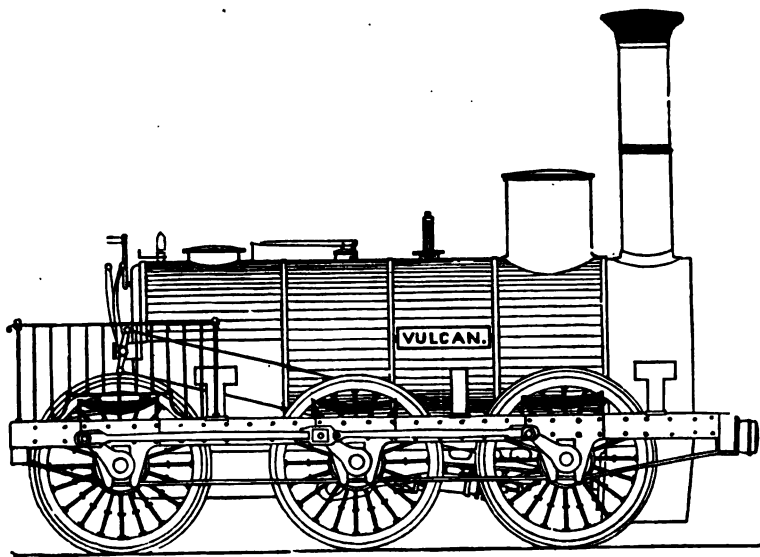


Fig. 39.—"Vulcan," No. 8, Leicester and Swannington Railway, 1835.

ward" forks were placed in or out of gear by one reversing lever; the valves were still retained above the cylinders.

The Newcastle and Carlisle Railway Company had the greatest objection to heavy engines, and to the concentration of weight; Messrs. R. Stephenson & Co.

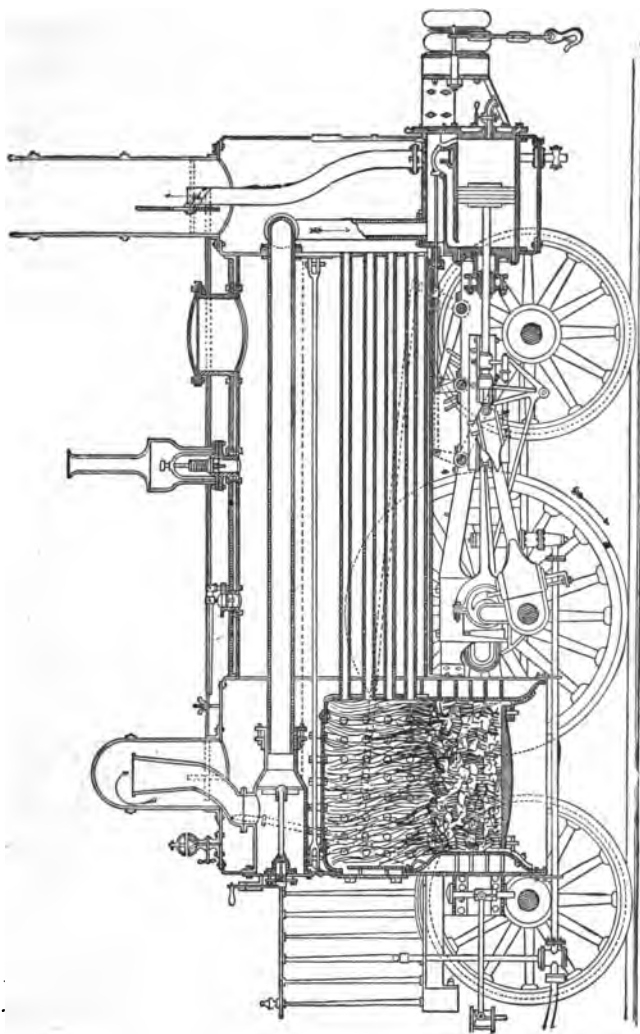


Fig. 40.—R. Stephenson's Standard Passenger Engine, 1836.

therefore built the "Atlas" (Fig. 41) for that line, in 1836, having cylinders 14 by 18, and six coupled wheels of 4 feet 6 inches diameter, the weight, however, in working order being only 11 tons 6½ cwt.

The "Ajax" (Fig. 42) was built by the Haigh Foundry Company, Wigan, and placed upon the Leicester and Swannington Railway, October, 1837; it had cylinders 14 by 18, and four coupled wheels 4 feet 6 inches diameter. The builders decided to employ tubes of 2¼ inches diameter instead of 1½ inches,

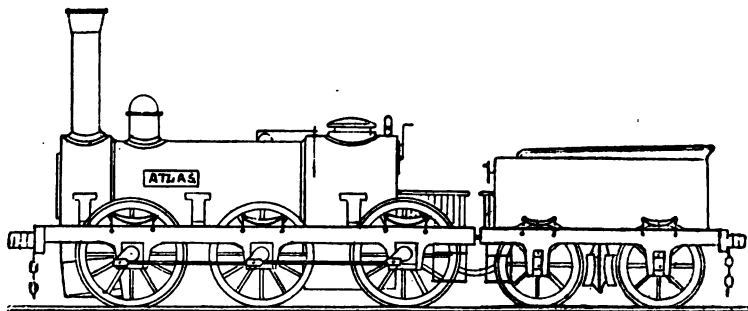


Fig. 41.—"Atlas," Newcastle and Carlisle Railway, 1836.

which was the usual practice at that date. Length of boiler between the tube plates 8 feet 8 inches. The valves were actuated by the "Haigh Foundry" gear, having four eccentrics and forked-ends to the eccentric-rods, the weight-bar shaft being placed *above* the eccentric-rod.

Messrs. Hawthorn constructed the "Swift," No. 26, for the Stockton and Darlington Railway; it was a four-wheeled engine with vertical cylinders, the connecting-rods working down to an intermediate shaft, coupled at each side to the wheel crank-pins by coup-

ling-rods. No. 27, for the same railway, was named the "Arrow," built by T. Hackworth in 1837, the cylinders were no less than 22 inches diameter, and the stroke only 9 inches. Neither of these engines was successful, and the designs were abandoned.

The first portion of the London and Birmingham Railway was opened July 20th, 1837, and the com-

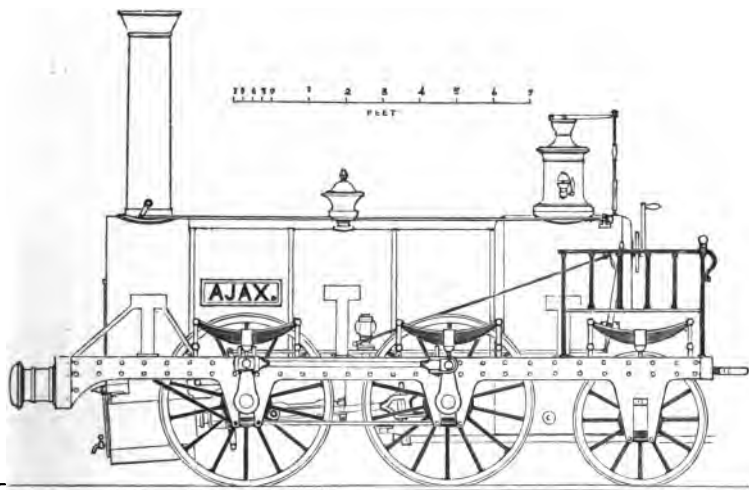


Fig. 42.—"Ajax," No. 9, Leicester and Swannington Railway, 1837.

pleted line September 17th, 1838. Mr. Edward Bury, of Liverpool, on becoming locomotive superintendent at Wolverton, unfortunately induced the directors to accept his views in favour of four-wheeled engines. The whole of that company's locomotive stock (with one exception) therefore had only four wheels. The passenger engines had single driving-wheels, 5 feet 6 inches diameter, and the "goods" had four coupled wheels, some 4 feet 6 inches and others 5 feet dia-

meter, the goods engines being of very similar construction to the "Liverpool," illustrated (Fig. 36).

Soon after Messrs. Stephenson adopted the engine

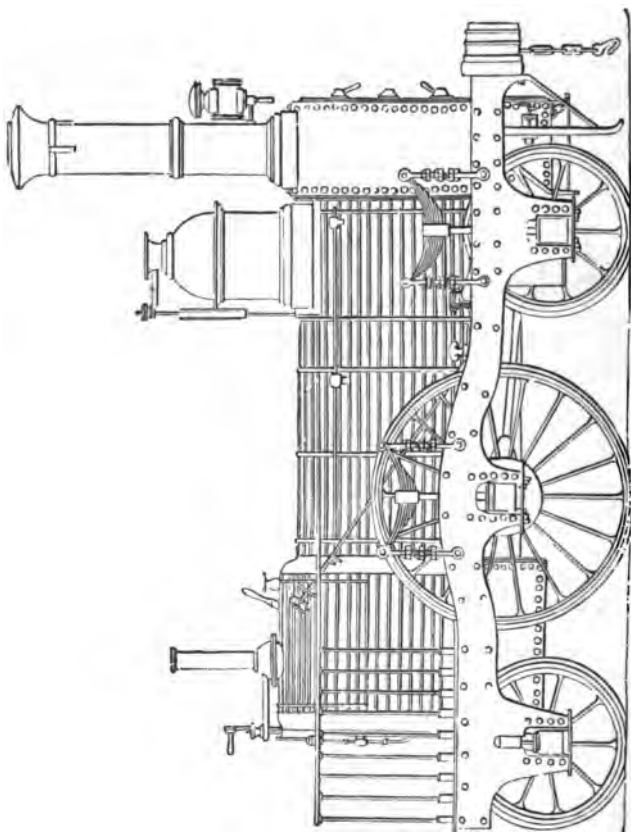


Fig. 43.—Sharp's Standard Passenger Engine, 1837.

(Fig. 40) as their standard passenger locomotive. Messrs. Sharp, Roberts & Co., of the Atlas Works, Manchester, adopted the design shown (Fig. 43).

During the year 1837 Sharp, Roberts & Co. placed several of their standard engines upon the Grand Junction Railway, named—

"Centaur" .. No. 12	"Wizard" .. No. 21
"Caliban" .. " 17	"Basilisk" .. " 22
"Cerberus" .. " 18	"Vizier" .. " 23
"Doctor Dalton" .. " 19	"Sirocco" .. " 24
"Eagle" .. " 20	"Harpy" .. " 25

All these had cylinders $12\frac{1}{2} \times 18$ and driving wheels 5 feet diameter, their weight when empty being 12 tons 5 cwts.

The design illustrated (Fig. 43) continued to be Sharp's standard pattern for nearly twenty years, and many hundreds of engines were built—their size and power of course increasing from $12\frac{1}{2}$ inch cylinders to 17 inches, and the driving wheels from 5 feet to 6 feet 6 inches; and several engines of this old design were at work till a very few years ago, and it is even believed that a few can be found on small branches at the present day.

CHAPTER III.

THE COMMENCEMENT OF THE BATTLE OF THE GAUGES.

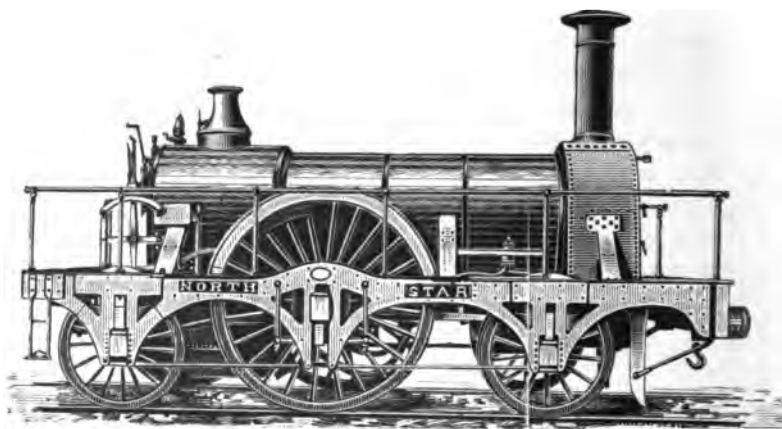


Fig. 44.—“North Star,” No. 1, Great Western Railway, 1837.

So far it has only been necessary to refer to engines running upon the ordinary 4 feet 8½ inch gauge, that being the only width employed in this country, with the exception of a gauge of 4 feet 6 inches on a few Scotch lines. However, Mr. Brunel, when laying out the Great Western Railway, unfortunately decided to adopt a broad gauge of 7 feet, and Parliament unwisely permitted the introduction of various gauges.

The broad gauge, however, although practically unnecessary and financially a failure, did more than anything else to improve and develop the locomotive engine, by creating the rivalry known as the "battle of the gauges," which lasted for fully fifteen years.

The directors of the Great Western Railway having appointed Mr. (afterwards Sir Daniel) Gooch as locomotive superintendent, the duty devolved upon him to design and provide the necessary engines.

Mr. Gooch, having inspected all the locomotives on other railways, considered that 5 feet 6 inch wheels were far too small; he therefore designed the engines for the Great Western with driving-wheels of 6, 7, and 8 feet diameter, and placed orders for their construction with the leading builders of that time. The first engine delivered on the line was the "North Star" (Fig. 44), constructed by R. Stephenson & Co., 1837. It was No. 1 in the books of the railway company, and No. 150 in those of the makers, the following being the chief dimensions:—

Wheels—Diameter of driving	7ft.
Diameter of leading and trailing	4ft.
Cylinders—Diameter	16in.
Stroke	18in.
Boiler—Length of barrel	9ft. 5in.
Diameter of barrel	3ft. 11in.
Number of tubes	167.
Length of tubes	9ft. 10½in.
Diameter (outside)	1½in.
Copper—fire-box—Length	3ft. 5½in.
Width	3ft. 10½in.
Height	4ft. 4½in.
Heating surface—Fire-box	94 sq. ft.
Tubes	756 sq. ft.
Total	850 sq. ft.
Fire-grate area	11·76 sq.

The "North Star" ran a trial trip January 1st, 1838,

and commenced daily work when the first portion of the Great Western Railway was opened to Maidenhead, on June 4th, 1838.

It continued at work for thirty-two years, and ran a distance of 429,000 miles, and is still preserved at Swindon Works, and at the present time it is under consideration to place this interesting relic in the South Kensington Museum.

Messrs. Stephenson also constructed several other engines of very similar design, named "Morning Star," "Evening Star," "Dog Star," "Polar Star," for the same railway.

The "Vulcan," the "Æolus," and the "Bacchus," built by Tayleur & Co., 1837, had 8-feet driving-wheels, the axle-boxes for which were placed above the framing as in the "Planet" (Fig. 20), and on the opening day of the Great Western Railway "Æolus," ran the distance from Maidenhead to London at an average speed of twenty-four miles an hour, including three stoppages.

The Grand Junction Railway, opened 4th July, 1837, formed a very important link, connecting the London and Birmingham Railway, at Birmingham, with the Liverpool and Manchester Railway at Newton Junction. Mr. Locke, the company's engineer, decided that all the locomotives should run on six wheels. The passenger engines were designed and ordered to have driving-wheels of 5 feet 6 inches diameter, but in view of the larger wheels introduced by Messrs. Brunel and Gooch, and the taunts of the advocates of the broad gauge that the narrow gauge could not have large wheels, it was decided that a few of those engines (the construction of which had not proceeded too far) should

be provided with 6-foot wheels, one of which is illustrated (Fig. 45).

This locomotive was constructed by the Haigh Foundry Company, and delivered September 20th,

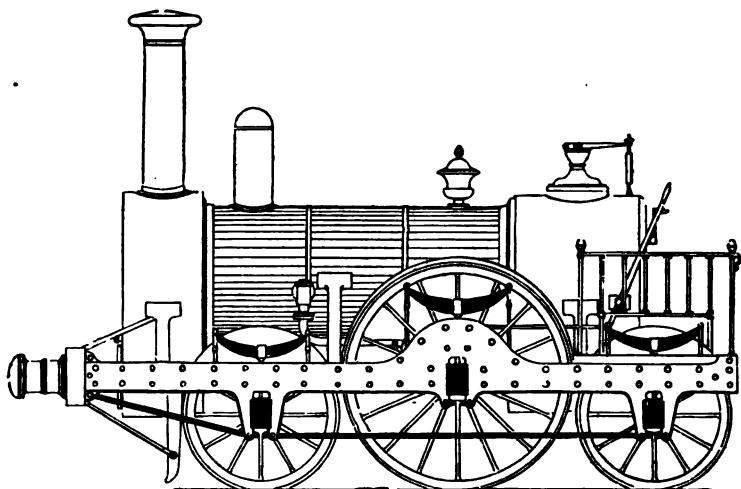


Fig. 45.—Grand Junction Railway, 1838.

1838, and is interesting, showing as it does a good specimen of narrow-gauge engine of that period.

Diameter of driving wheels	6 feet 0 inch.
Diameter of carrying wheels	4 " 0 "
Diameter of cylinders (13½)	1 " 1½ "
Length of stroke (18)	1 " 6 "
Number of tubes, 102	
Diameter of tubes inside	0 " 2 "
Heating surface of tubes	480 square feet.
Heating surface of fire-box	58 square feet.
Total	538 square feet.

The valve gear consisted of the Haigh Foundry pattern, having four fixed eccentrics. Engines of this class

THE LOCOMOTIVE.

worked with great efficiency upon the Grand Junction and other railways for many years.

Mr. T. E. Harrison, in December, 1836, designed, and during 1837-8, Messrs. Hawthorn constructed, two locomotives for the Great Western Railway. These engines had the cylinders and motion upon a separate frame and wheels from the fire-box and boiler.

One of these named, the "Thunderer," had wheels 6 feet diameter, but geared up, three to one, in order to be equal in effect to a wheel 18 feet in diameter.

The other, named "Hurricane," had a pair of driving-wheels 10 feet diameter, the largest ever made, illustrated (Fig. 46).

The boiler, fire-box, and frame upon which they were placed, also the tender, were of the same dimensions in each case. The cylinders and stroke were also similar.

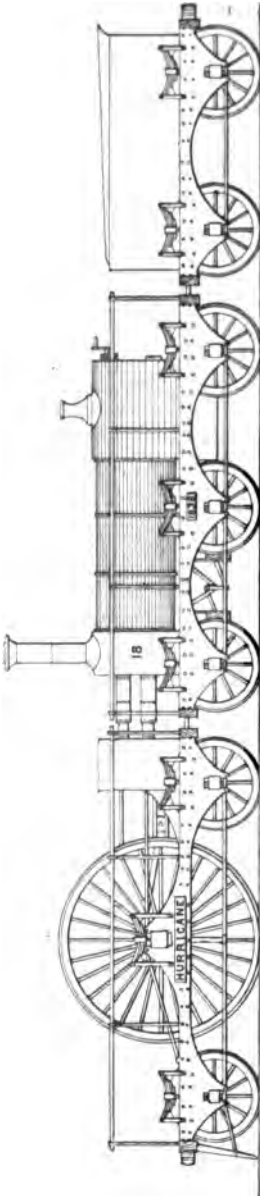


Fig. 46.—The "Hurricane," 1838.

The following are the dimensions of the "Hurricane."

Diameter of driving wheels	10 feet
Diameter of cylinders	16 inches
Length of stroke	20 inches

The boiler contained 135 brass tubes. The fire-box was of copper, and divided by a mid-feather.

Heating surface of tubes	516 square feet
Heating surface of fire-box	108 square feet
Total	624 square feet

Weight of the six-wheeled engine 11 tons, of which 6 tons rested upon the 10-foot driving wheels. The weight of the six-wheeled frame with the boiler and fire-box was 12 tons.

The steam from the boiler to the cylinders was conveyed by a jointed pipe and the exhaust steam was returned to the chimney by a similar pipe. The engine-driver stood upon the engine in front of the driving axle, and the fireman behind the fire-box in the usual way. Both of these extraordinary engines proved failures, one great cause being that there was so little weight available for adhesion.

An examination of Fig. 46 shows that the "Hurricane" had a good sound framing, and there is every reason to believe that if the boiler had been placed over the driving axle, instead of on an independent frame, the engine would have been considerably improved.

The Arbroath and Forfar Railway, when opened on the 3rd January, 1839, had a gauge of 5 feet 6 inches, and during the year 1838, Messrs. Stirling & Co., of Dundee, designed and constructed three locomotives for that line, named "Victoria" (Fig. 47), "Britannia," and "Caledonia."

Messrs. Stirling, having visited the Liverpool and Manchester Railway, and examined the "Swiftsure"

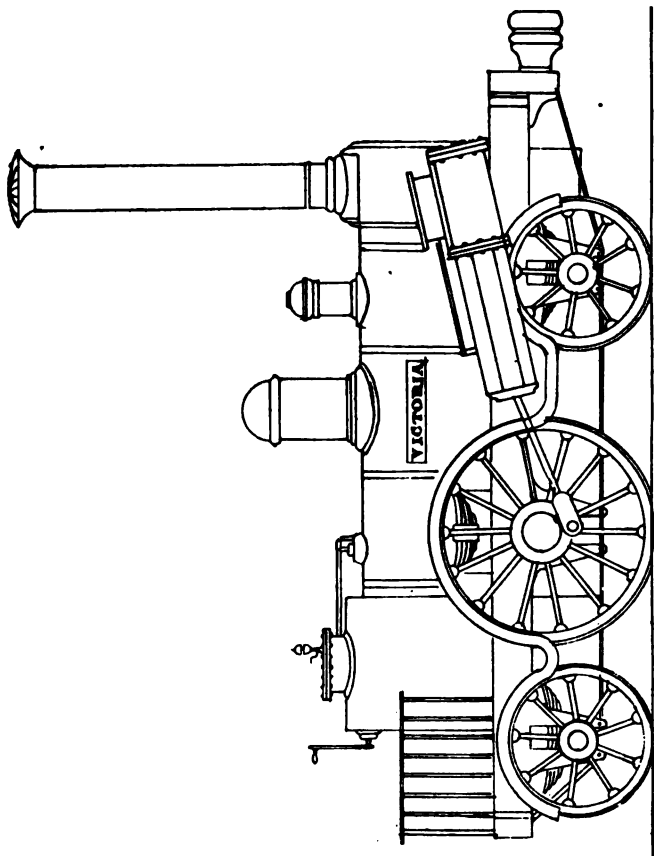


Fig. 47.—"Victoria," built by Stirling & Co., 1838.

(Fig. 37), came to the conclusion that an outside frame was unnecessary. The Arbroath and Forfar engines were therefore the first to combine inside bearings,

outside cylinders, and six wheels ; they had cylinders 12 by 18 ; driving-wheels 5 feet diameter. These locomotives worked very satisfactorily for many years, and until the line was leased to the Caledonian Company and the gauge altered to 4 feet 8½ inches.

The Haigh Foundry Company, Wigan, constructed

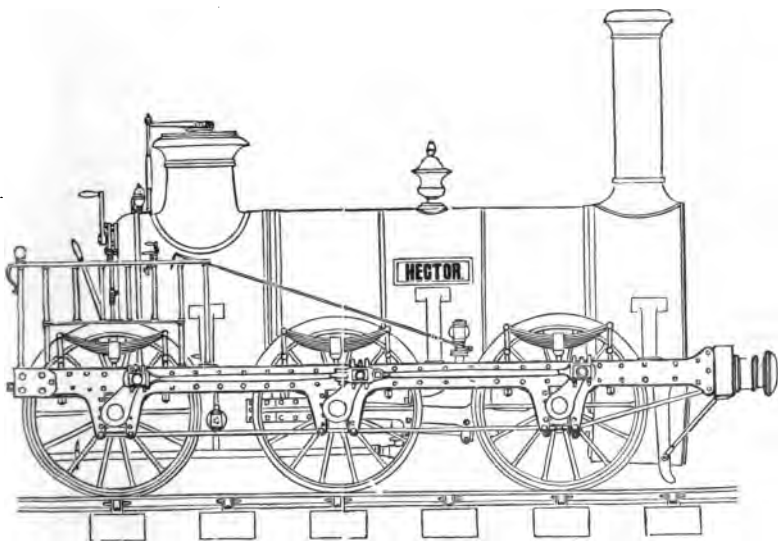


Fig. 48.—“Hector,” No. 10, Leicester and Swannington Railway, September, 1839.

the “Hector” (Fig. 48), for the Leicester and Swannington Railway, and it commenced work upon that line, September, 1839.

“Hector” was a six-wheeled coupled goods engine, having cylinders 16 inches by 20 inches, and wheels 4 feet 6 inches diameter. Total heating surface, 688 square feet.

The valve gear was the "Haigh Foundry" pattern, having four fixed eccentrics, and forked ends to the eccentric-rods; the boiler was "clothed" with sheet iron plate instead of with polished wood, which was the usual practice at that time. The driving-wheels were without flanges. This locomotive was constructed to work with a steam pressure of 120 lbs. per square inch if necessary, but for the first few years it was only worked with 80 to 90 lbs. The urn-shaped vase upon the boiler contained a "lock-up safety valve" pressed to blow off at 91 lbs.

The "Hector," was regarded as such a powerful engine that invitations were issued to the locomotive officials of the other companies to witness its performance between Coalville and Bagworth, and as a result similar engines were ordered for the Manchester and Leeds, North Midland, Great Western, and Liverpool and Manchester Railways.

The first part of the Birmingham and Gloucester Railway was opened 24th June, 1840; this line was intended to form a portion of a great through-route between the north and west of England; it was, therefore, a very serious mistake on the part of the engineer, Captain Moorsom, to have designed and constructed the great Lickey incline of 1 in 37 for a distance of over two miles, extending from Bromsgrove to Blackwell, and it was an equal mistake to suppose that English locomotive builders could not construct an engine to ascend the incline. However, he ordered eight locomotives from Norris & Co., of Philadelphia, the first four to arrive being named "England," "Philadelphia," "Columbia," and "Atlantic." These engines had a four-wheeled leading bogie, a single

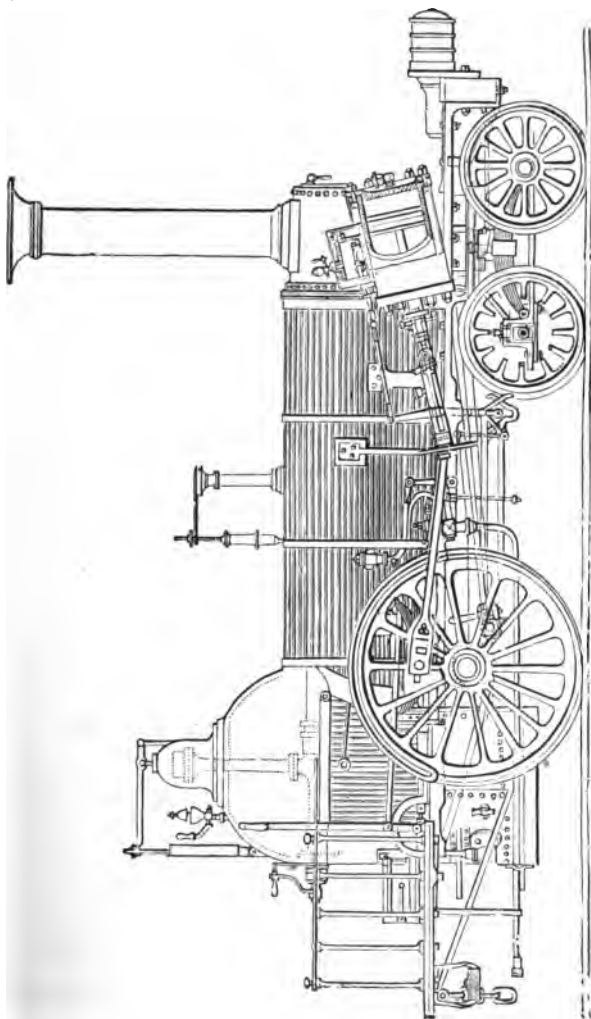


Fig. 49.—“Philadelphia,” Birmingham and Gloucester Railway, 1840.

pair of driving-wheels placed in front of the fire-box, and outside inclined cylinders.

Diameter of cylinders..	..	..	..	..	..	10½ ins.
Length of stroke ..	..	..	..	..	..	18 ins.
Diameter of driving-wheels	..	..	..	..	..	4 ft.
Weight in working order ..	..	..	..	..	..	9 tons 11¼ cwts.

Their usual performance up the "Lickey" was 33 tons at 12 to 15 miles per hour, 39½ tons at 10½ miles, or a maximum load of 53¼ tons at 8½ miles.

One of these American engines having 11½ cylinders was lent for a few weeks for trial upon the Grand Junction Railway, when it was ascertained that it conveyed loads of 100 to 120 tons on an incline of 1 in 330 at 14 to 22½ miles per hour; or on an incline of 1 in 177 at 10 to 14 miles per hour. The mean of seven journeys from Birmingham to Liverpool, with gross loads of about 100 tons, showed a consumption of 50 lbs. of coke per mile, and an evaporation of 4·27 lbs. of water per pound of coke.

The American engines having worked with great success upon the Lickey incline for a few weeks, Mr. Edward Bury, of Wolverton, wrote to the directors "to declare that whatever American engines could do his could do," and sent the London and Birmingham Company's engine named "Bury" to prove his assertion.

Mr. Bury, himself driving, started from Bromsgrove, and humorously called to Mr. Gwynn, who had come with the American engines, to join him. "No," he replied, "it's no use, you'll soon come back again," and back again Mr. Bury and his engine came, having stuck before getting half-way up the incline.

In consequence of the taunts which appeared in an

American newspaper, that "the English could make inclines, but had to come to America for engines to work them," Mr. J. E. McConnell, the locomotive superintendent of the Birmingham and Gloucester Railway, obtained the sanction of his directors to construct a powerful tank engine at the Bromsgrove works, and it commenced duty in 1845.

This engine had six coupled wheels of 3 feet 9 inches diameter, cylinders 18 inches diameter, a stroke of 26 inches, and a total weight of 30 tons loaded. This engine worked successfully for a number of years.

Mr. Robert Stephenson's attention was given, early in the year 1842, to the fact that the chimneys and smoke-boxes were very quickly destroyed; he therefore made some experiments with North Midland Company's engines at Derby to ascertain the degree of heat which was escaping. First he placed tin in small iron conical cups and suspended them in the "smoke box," and it was found to disappear quickly; next, lead was tried in the same manner, and was found to melt nearly as easily; and, lastly, zinc was tried, which was soon driven off in vapour, clearly indicating a temperature of 773 degs. in the chimney, and showing that a great waste was taking place. To overcome this evil, Mr. Stephenson decided to lengthen the tubes of locomotives from 9 ft. to 13 or 14 ft., but he found that to obtain a patent for the invention he would have to employ an unlimited term, as to fix a length would be useless, as a few inches more or less would enable others to evade the patent; he therefore adopted the name "long boiler," and placed all the axles under the barrel or circular part of the boiler.

In the first of these "long-boiler" engines, the

driving-wheels were placed between the fore and hind carrying-wheels, the cylinders being kept forward to

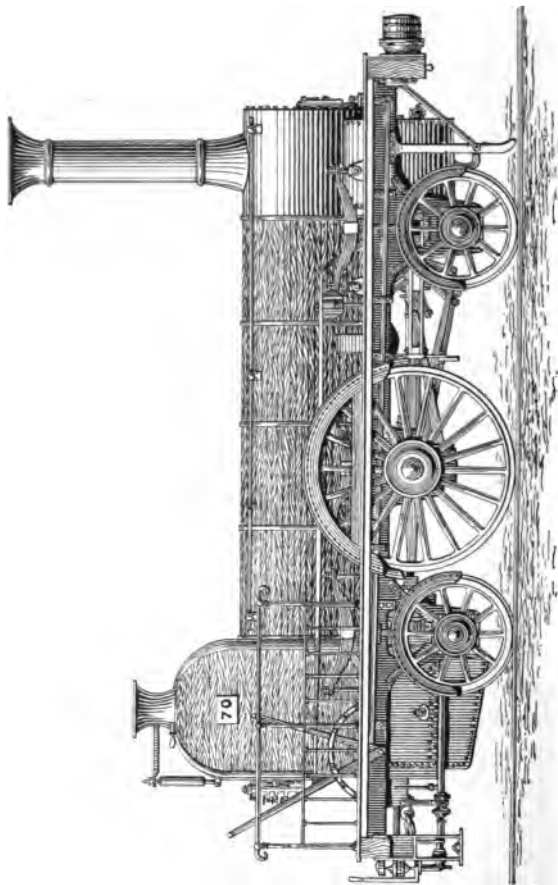


Fig. 50.—North Midland Railway, No. 70, 1842.

the outside of the smoke-box (Fig. 50). Several engines of this design were built for the North Midland Railway Company and other lines.

Further experiments at Derby in 1843 proved that the "long-boiler" was successful in reducing the heat in the chimney to very little over 442 degs., as upon placing tin in the smoke-box it was found just to melt at the corners.

In 1844 Mr. Robert Stephenson decided to place the four carrying-wheels in front and the driving-wheels close in front of the fire-box; in 1846 he added a pair of trailing wheels behind the fire-box, thus converting his long-boiler engine into an eight-wheeled locomotive.

In the year 1846 it was reported that at least 150 locomotives, according to this long-boiler pattern, were in constant use in this country and on the continental railways.

Valve-gear having loose eccentrics (described p. 45) was found to be far from satisfactory, and many other gears were tried—for instance, those of Carmichael, Hawthorn, Haigh Foundry, Stephenson, Gray, Dodd and others—but none of these fulfilled all that was necessary. The eccentric-rods in nearly all valve gears, previously to 1842, were provided with "forks" or "gabs," which engaged with pins attached to the arms of the valve rods. In practice these pins were frequently broken off.

Stephenson's valve-gear, generally known as "fork motion," is illustrated in Fig. 51, and shows the form of gear used by that firm between the years 1835 and 1842.

Mr. William Howe, who was a fitter in the employ of R. Stephenson and Co., decided to place a curved link between the ends of the forward and backward eccentric-rods to take the place of the forks. He

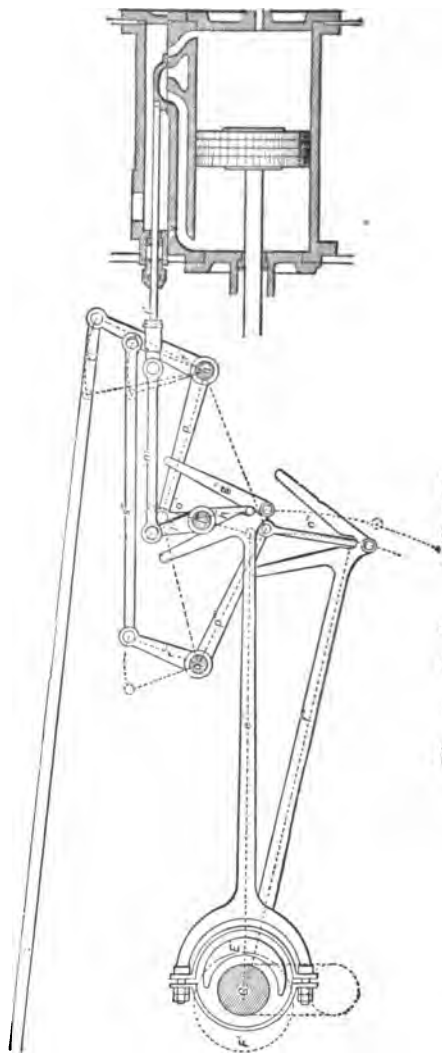


Fig. 51.—Stephenson's Fork Motion, 1835 to 1842.

made a pencil sketch and wooden model, which were shown to Mr. Robert Stephenson, who, seeing its merits, ordered it to be fitted to all engines constructed at his works. At that time (August, 1842) two locomotives were being built for the North Midland Railway, Nos. 70 and 71. No. 70 was already fitted with "fork motion," but No. 71 was supplied with Howe's link motion (Fig. 52), and commenced to run on September 10, 1842.

Some correspondents to newspapers have expressed the opinion that "the introduction of the 'link' was not an invention, but an improvement." By whichever name it be known, the fact remains that Mr. Howe's introduction of the link at once removed all the difficulties which had for years caused trouble with the "fork motion," and it did far more than this, by producing a complete and simple means of cutting off steam for expansive working.

It has also been contended that "the merits of the gear for 'cutting off' were probably not known at first." Now, as a fact, the reversing lever rack of the

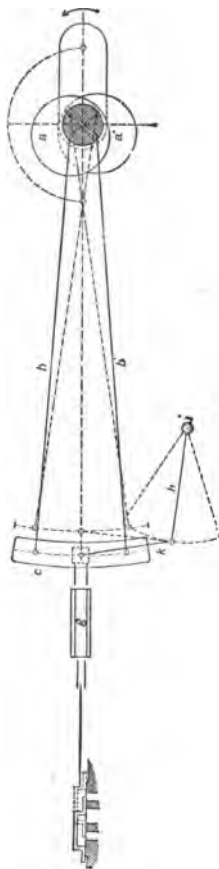


Fig. 52.—Howe's Link Motion, 1842.

first engine ever fitted with link motion had seven notches on either side of the centre, and steam could be cut off at various proportions of the stroke, from $4\frac{1}{4}$ inches to $17\frac{1}{8}$ inches. It is therefore perfectly certain that the expansive working of the gear was fully understood before the first engine left the Newcastle works, for had it not been intended to work expansively, "the seven notches on either side of the centre" would have been useless. There is also conclusive proof that the action of the gear was fully understood by Mr. Howe, for he came himself to the North Midland Railway with the engine No. 70 in order to instruct the engine-driver how to work his gear to the best advantage. Howe's link motion was at once adopted by nearly all locomotive builders, it is in use in all parts of the world, and to this day there is no valve gear to equal it. The "link motion" is frequently spoken of as Stephenson's, but this is an error, as Howe was the inventor, and Mr. R. Stephenson himself always spoke of it as Howe's.

Mr. Alexander Allan (whose death only took place in 1891) entered the service of the Grand Junction Railway Company, February, 1840, and took charge of that company's locomotive establishment at Edge Hill, Liverpool, under Mr. Buddicom, the chief mechanical engineer. From the copy of the official list in the writer's possession, it appears that, at the close of the year 1839, the Grand Junction Company possessed 59 engines. These all ran upon six wheels, had double frames and inside cylinders, 57 of them had "single" driving-wheels, and two, "Sirius," No. 30, and "Gorgon," No. 41, were the only "goods" engines, they having the leading and driving-wheels coupled.

Names and numbers of the Grand Junction Company's engines, 1837 to 1840 :—

1. Saracen.	21. Wizard.	41. Gorgon.
2. Hecla.	22. Basilisk.	42. Sunbeam.
3. Shark.	23. Vizier.	43. Vampire.
4. Hecate.	24. Sirocco.	44. Harlequin.
5. Falcon.	25. Harpy.	45. Sybil.
6. Stentor.	26. Æolus.	46. Medea.
7. Scorpion.	27. Merlin.	47. Vulture.
8. Wildfire.	28. Prometheus.	48. Oberon.
9. Aleto.	29. Alaric.	49. Columbine.
10. Dragon.	30. Sirius.	50. Hornet.
11. Zamiel.	31. Pegasus.	51. Torch.
12. Centaur.	32. Tamerlane.	52. Diomede.
13. Prospero.	33. Erebus.	53. Clio.
14. Witch.	34. Phœbus.	54. Medusa.
15. Phalaris.	35. Talisman.	55. Lucifer.
16. Lynx.	36. Thalaba.	56. Phantom.
17. Caliban.	37. Hawk.	57. Sultan.
18. Cerberus.	38. Camilla.	58. Syren.
19. Dr. Dalton.	39. Tartarus.	59. Vandal.
20. Eagle.	40. Jason.	60. Tantalus.

Upon taking charge, Mr. Allan found that three engines, namely, "Æolus," 26, "Tartarus," 39, and "Sunbeam," 42, were in a very bad condition, having broken crank-axles and defective framings; he therefore decided to rebuild them.

Mr. Allan's experience as manager of Messrs. Forrester's works had led him to become an advocate of outside cylinder engines; he therefore converted the three above-mentioned engines from inside cylinder to outside; the leading and trailing wheels had outside bearings as previously, but the driving-wheels had the outside bearings removed, and the connecting-rod placed direct upon a crank-pin upon the boss of the wheel. The broken crank-axle was of course in each case replaced by a straight axle.

The first of these rebuilt engines, "Æolus," was put to work towards the close of the year 1840, "Tartarus" and "Sunbeam" following in 1841. At this period the Grand Junction Railway Company decided to build locomotive works at Crewe, and to construct its own engines. The Crewe works were opened early in the year 1843, Mr. Allan taking charge thereof as superintendent, Mr. F. Trevithick being the company's chief mechanical engineer.

Mr. Allan designed and constructed the passenger engines upon the model of the rebuilt "Æolus," and employed driving-wheels of 5 feet 6 inches and 6 feet diameter, the cylinders placed outside, being 15 inches and the stroke 20 inches.

The goods engines (Fig. 53) were of a similar design, but the driving and trailing wheels were 5 feet diameter and coupled, the cylinders being outside and 15×20 .

These two classes became generally known as the "Crewe pattern," and when, on July 16, 1846, the Grand Junction, London and Birmingham, and Manchester and Birmingham companies amalgamated and became the London and North-Western Railway, Mr. Allan continued to build his Crewe pattern for the northern division of that railway. He was also the inventor of the "Allan straight link motion."

The goods engines (Fig. 53) were 22 feet 5 inches in length over buffers, and their weight in working order $19\frac{1}{2}$ tons; they conveyed the goods and mineral traffic on the northern division of the London and North-Western Railway for many years, and, when superseded by Mr. Ramsbottom's six-coupled engines, they were converted into tank engines for

branch passenger traffic, and some of them are at work at the present day.

During the year 1843 the London and South-Western Railway adopted outside cylinder engines of similar design to those introduced upon the Grand Junction Railway at Crewe. The locomotive superintendent, Mr. John V. Gooch, constructed some of these engines with driving-wheels of 6 feet 6 inches, and others with

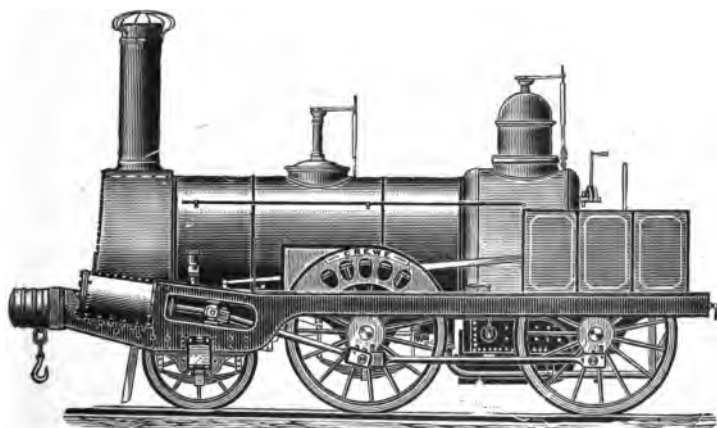


Fig. 53.—Mr. Allan's Goods Engines, Crewe Works, 1843 to 1857.

7 feet wheels, the largest then in use on the narrow gauge.

In December, 1845, a series of experiments was conducted upon the Great Western Railway, between London and Didcot, with an engine named "Ixion" having inside cylinders $15\frac{3}{4}$ inches diameter and 18 inches stroke; four carrying-wheels; driving-wheels, 7 feet diameter; grate, 13.4 feet; surface of fire-box, 97 feet; tubes, 2 inches diameter, 131 in number, surface

732 feet; total heating surface, 829 feet; weight, empty, 22 tons; weight of tender, empty, 8 tons. This engine attained a maximum speed of 62 miles per hour with an average load of $76\frac{1}{2}$ tons, and an average speed of 50 miles on a trip of 53 miles; the coke consumed was at the rate of 35·3 lbs. per mile, and water evaporated 201·5 feet per hour.

Mr. T. R. Crampton took out a patent in 1843 for an arrangement or position of locomotive wheels, in which the small, or carrying-wheels, were placed in front and the large driving-wheels at the trailing end, behind the fire-box; the cylinders being outside. It was claimed that this design solved the problem of obtaining a large driving-wheel with a low centre line of boiler. (The idea, however, was not quite new, as in 1833 Mr. Baldwin, in America, constructed several engines having the driving-wheels behind the fire-box.)

During the year 1846 Messrs. Tulk and Ley constructed two engines at the Lowca works, Whitehaven, from the designs of Mr. Crampton, for the Namur and Liège Railway, and they were named "Namur" and "Liège."

These engines ran upon six wheels, and had outside cylinders, 16 × 20, and a pair of 7 feet driving wheels placed behind the fire-box.

In practice the performance of these two engines was found to be equal to a load of 80 tons, exclusive of engine and tender, at 51 miles per hour on a level; and 50 tons at 62 miles per hour on the level.

Before exportation the "Namur" was tried experimentally upon the London and North-Western Railway, and attained a higher speed than any broad-

gauge locomotive at that period; this result giving the greatest satisfaction to the narrow-gauge advocates.

In 1846 Messrs. Stephenson and Howe patented a three-cylinder locomotive having two outside and one inside cylinder in order "to counteract the alternate lifting on the opposite side of the engine." Two of these engines were constructed and tried experimentally; they worked satisfactorily. As is the case with the three-cylinder locomotives in use at the present day, these engines had three sets of motion to be provided and maintained; however, when new they ran at a higher speed than the broad-gauge engines.

At this period the battle of the gauges was at its height and the rivalry was most keen; the Royal Commission had been appointed July, 1845, to decide between the "broad" and "narrow" gauges.

During the years 1838 to 1845, Mr. Bury was strongly urged by the narrow-gauge advocates to build some larger engines for the London and Birmingham Railway in order to compete with the Great Western Railway. This, however, he firmly refused to do, and was perfectly content to continue to place the small four-wheeled engines on that line, and a list now before us shows that even in August, 1845, the company had 89 four-wheeled engines and one six-wheeled ballast engine. There can be no question that the broad gauge gained many friends, in London especially, on account of Mr. Bury continuing to run small four-wheeled engines to London. The advocates of the broad gauge, of course, urged the public to compare the large six-wheeled engines at Paddington with the little four-wheelers at Euston. Thus it

will be seen that Mr. Bury, although himself opposed to the broad gauge, by his policy played into the hands of the broad-gauge advocates ; indeed it was remarked at the time that Mr. Bury did more harm to the narrow gauge cause than any of its enemies.

The narrow-gauge engines were successfully maintaining their position (upon every line but the London and Birmingham), and proving that whatever could be done upon the 7 feet gauge could be equally well done on the 4 feet 8½ inches gauge. It therefore became necessary for the Great Western Company to make some "striking improvement" in order to show what could be obtained upon the broad gauge, and Mr. (afterwards Sir Daniel) Gooch, the company's locomotive superintendent, accordingly designed and constructed at the Swindon works a new and very powerful class of express engine which he regarded as the "ultimatum" for the broad gauge.

The first of this class was named "Great Western," and commenced work April, 1846.

The engine (Fig. 54) has eight wheels—namely, four leading-wheels arranged in a group (but not in a bogie), a single pair of driving-wheels 8 feet diameter, having no flanges, and a small trailing pair of wheels. The cylinders 18 by 24, 300 tubes, and 1,767 square feet of heating surface. The valve gear was the well-known fixed link motion introduced by Mr. Gooch.

This splendid locomotive was highly successful, and was found capable of evaporating 300 cubic feet of water per hour, and it is a noteworthy fact that engines of this class appear to be among the most economical ever run, the consumption of coal being as low as 2½ lbs. per horse-power per hour.

This engine upon several occasions started from Paddington and stopped at Didcot, $53\frac{1}{4}$ miles, in 47 minutes, and obtained a maximum speed of 78 miles

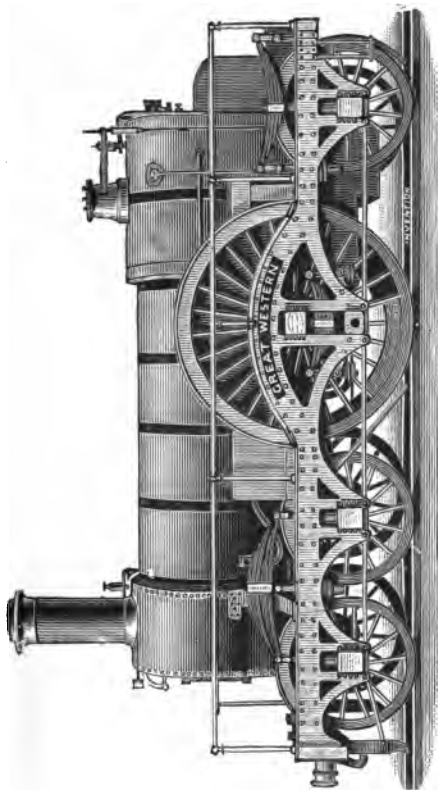


Fig. 54.—"Great Western," Great Western Railway, 1846.

an hour. 29 other locomotives were built between 1847 and 1855 similar to Fig. 54; most of these (of course with new boilers) were still at work till May, 1892.

Through the courtesy of Mr. William Dean, loco-

motive superintendent of the Great Western Railway, the complete list of the 30 engines is given, showing the miles run before being "rebuilt":—

BROAD GAUGE ENGINES, "GREAT WESTERN" CLASS.

Name of Engine.	Builder.	Date.		Total mileage before renewal.
		Built.	Condemned or rebuilt.	
Great Western	G.W.R.	April.. 1846	Dec... 1870	370,687
Iron Duke	"	" .. 1847	Oct... 1871	607,412
Lightning	"	" .. "	April 1878	816,601
Great Britain	"	July .. "	Oct... 1880	403,644
Emperor	"	Sept.. "	June 1873	690,225
Pasha	"	Nov. .. "	" 1876	613,038
Sultan	"	" .. "	Aug. "	727,300
Courier	"	June .. 1848	Nov. 1877	746,120
Tartar	"	July .. "	Aug. 1876	731,817
Dragon	"	Aug... "	Dec... 1872	670,757
Warlock	"	" .. "	June 1874	639,410
Wizard	"	Sept.. "	Nov. 1875	711,908
Rougemont	"	Oct. .. "	Aug. 1879	772,401
Hirondelle	"	Dec. .. "	May 1873	605,010
Tornado	"	March 1849	March 1881	688,000
Swallow	"	June .. "	Aug. 1871	569,232
Timour	"	Aug... "	Nov. "	569,893
Prometheus	"	March 1850	June 1870	538,025
Perseus	"	June .. "	Dec... 1880	722,458
Estafette	"	Sept.. "	June 1870	504,544
Rover	"	" .. "	" 1871	461,344
Amazon	"	March 1851	July 1877	729,840
Lord of the Isles, built 1850, commenced work July, 1852	"	July .. 1852	" 1881	789,300
Alma	Rothwell	Nov... 1854	June 1872	444,600
Balaclava	"	Dec. .. "	Nov. 1871	406,425
Inkerman	"	March 1855	Oct... 1877	650,220
Kertch	"	April.. "	Dec... 1872	326,246
Crimea	"	May .. "	Sept. 1878	605,701
Eupatoria	"	" .. "	Oct... "	618,275
Sebastopol	"	July .. "	" 1880	707,148

The "Lord of the Isles," built 1850, was sent to the Exhibition of 1851, also to the Edinburgh Exhibition of 1890, and with the removal of the broad gauge on the 23rd May, 1892, the whole of this type of engines necessarily ceased from their labours; but one is now being sent to the Chicago Exhibition.

The average consumption of coal of the whole of the engines of this class, when working on the Great Western Railway, was about 27 lbs. per mile.

Such facts as the above show that the late Sir Daniel Gooch took a very important part in the development of the locomotive.

The success of the "Great Western" (Fig. 54) at once caused the narrow-gauge lines to require larger engines. The London and North-Western Company gave orders to Messrs. Tulk and Ley for an engine, designed by Mr. Crampton; it was placed on the line in 1847, and named the "London"; this engine had cylinders 18 by 20, a single pair of 8 feet driving wheels and 1,529 square feet of heating surface; and it was claimed that with a light load she attained a speed of fully 74 miles an hour. The directors of the London and North-Western also gave instructions for the construction, at Crewe works, of three experimental engines:—

The "Courier," designed by Mr. Crampton, having a pair of 7-feet wheels placed behind the fire-box;

The "Velocipede," designed by Mr. Alexander Allan, the superintendent of the Crewe works, having a pair of 7-feet wheels; and

The "Cornwall," by Mr. F. Trevithick, the chief mechanical superintendent of the northern division; and they were all completed in 1847.

The "Courier" was a very similar engine to the "Namur" and others of Mr. Crampton's design.

Mr. Allan, of Crewe, held the opinion that the "battle of the gauges" was an absurdity, and that it was not wise to build engines simply to see *what could be done*; he therefore built the "Velocipede" (Fig. 55).

This engine had cylinders 15 by 20 and 7 feet wheels, and this class of engine proved highly successful in daily working on the northern division of the London and North-Western.

On the other hand Mr. F. Trevithick considered it a matter of the most vital importance that the "narrow gauge" should eclipse the performance of the broad gauge; he therefore decided to have a

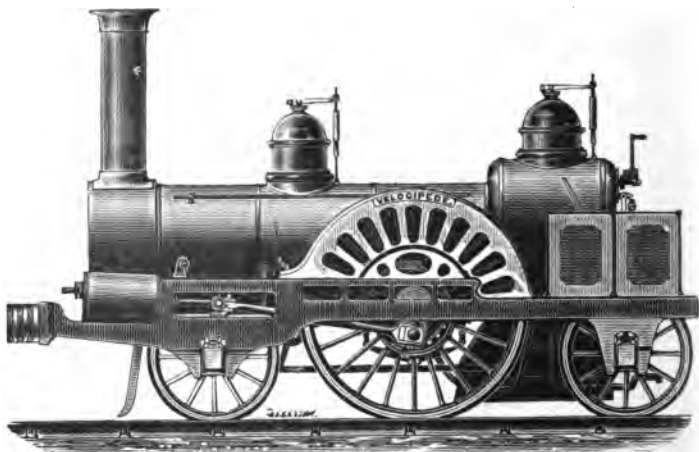


Fig. 55.—"Velocipede," No. 187, Crewe Works, Oct. 1847.

driving-wheel six inches larger than the "Great Western" (Fig. 54). In order to obtain a large driving-wheel and a low centre of gravity, he adopted the peculiar plan of placing the boiler *under* the driving axle. The driving-wheel of the "Cornwall" he designed of 8 feet 6 inches diameter, that being the largest size which had then, or has since, been tried upon the ordinary 4 feet 8½ inches gauge, the cylinders



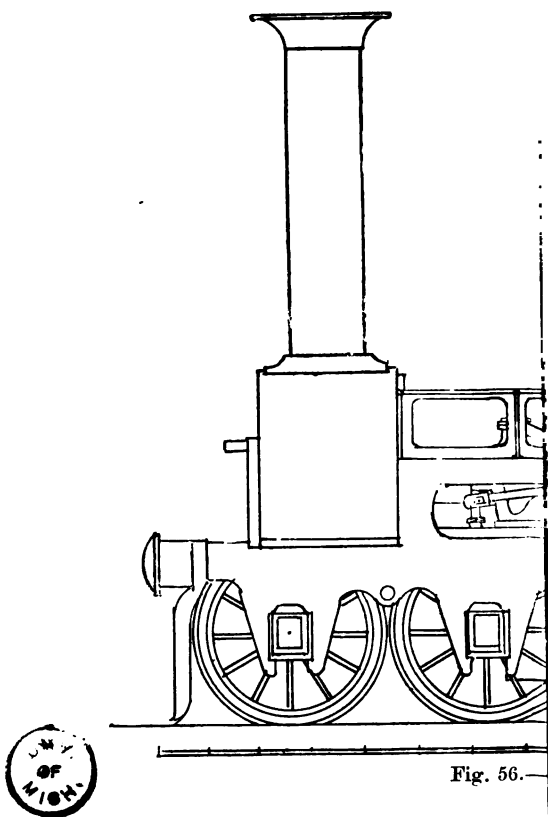


Fig. 56.

being $17\frac{1}{2}$ inches diameter, and 24 inches stroke. The engine (Fig. 56) appears to have fully answered the expectation of her designer, for upon the trial trip a speed of fully 79 miles an hour was attained under favourable circumstances, thus beating the "Great Western" by one mile per hour.

This locomotive engaged very considerable attention at the Exhibition of 1851, but no engineer favoured the position of the boiler, and about 1862—1863, Mr.

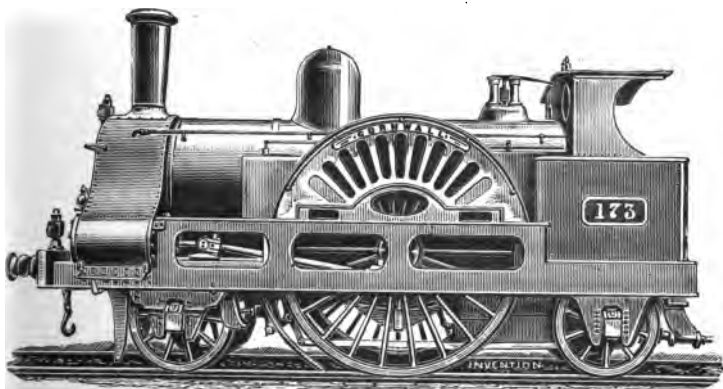


Fig. 57.—"Cornwall," London and North-Western Railway, 1863 to 1893.

John Ramsbottom constructed a new boiler and placed it *above* the axle.

Fig. 57 illustrates this fine engine as thus altered, and as it is running to-day.

The "Cornwall" is still working the "45 minute" expresses between Manchester and Liverpool, and carries us back to the year 1847, or for a period of over 45 years. It has now the largest wheel in the world, and it is stated that with a load equal to her power she

is capable of running at the highest possible speed yet attained.

The "Cornwall" appears capable of several years' more work, and, ultimately, when it rests from its labours it is understood that it is to be preserved as a relic of early locomotive construction.

Another large narrow-gauge engine intended to surpass the "Great Western" (Fig. 54) was designed by Mr. T. R. Crampton, and built by Messrs. Bury, Curtis and Kennedy, of Liverpool, for the London and

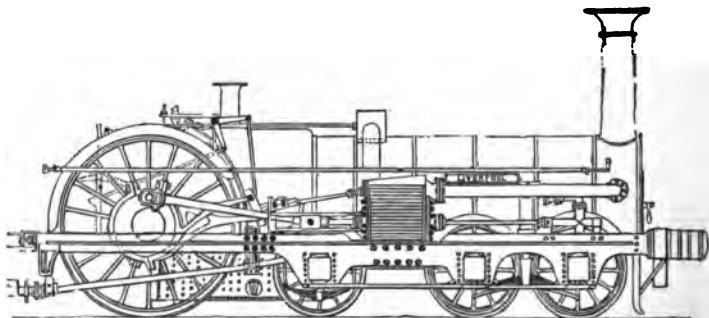


Fig. 58.—"Liverpool," London and North-Western Railway, 1848.

North-Western Railway, 1848, and named the "Liverpool" (Fig. 58), an engine generally considered as the "ultimatum for the narrow gauge."

The "Liverpool" had cylinders 18 inches diameter, 24 inches stroke; 292 tubes of $2\frac{3}{16}$ inches external diameter and 8 of $1\frac{3}{4}$ inch, 12 feet 6 inches long; surface of fire-box 154.434 feet; of grate $21\frac{1}{2}$ feet; of tubes 2136.117 feet; total heating surface 2,290 feet; two driving-wheels 8 feet diameter; 6 carrying-wheels 4 feet diameter; length between centres of extreme wheels

18 feet 6 inches; total length of engine 27 feet; weight of engine, charged, 35 tons, or 12 tons on the driving-wheels, 17 tons on the four leading wheels, and 6 tons on the two intermediate wheels; weight of tender 21 tons; total weight 56 tons. This engine conveyed the express trains between London and Wolverton for some time, and in one case took 40 carriages within time, thus exceeding the combined duty of three ordinary engines; and when tested for "speed" with a light load, the late Mr. Crampton informed the writer that it attained fully 79 miles an hour.

The permanent-way at that time was not strong enough to carry such a large engine, its weight and long rigid wheel-base therefore caused it to gradually retire from active service.

Had the rail-joints been "fished," and the four front wheels placed in a bogie frame, this would have been one of the most successful engines.

Shortly after the construction of the "Liverpool" Mr. T. R. Crampton, in 1849, designed a locomotive having inside cylinders but the driving-wheels fixed to a straight axle. He employed a double-cranked shaft, having also outside cranks and coupling-rod to communicate motion to the driving-wheels, which were placed behind the fire-box. Eight of these engines were ordered from Messrs. R. Stephenson and Co., and placed upon the South-Eastern Railway, and one of these, the "Folkestone," was sent to the Exhibition of 1851. Engines of this class took 44 tons at an average speed of $65\frac{1}{2}$ miles an hour, and attained $73\frac{1}{2}$ miles per hour upon a falling gradient of 1 in 264; they were, however, not satisfactory, and were rebuilt with driving-wheels upon the driving-shaft.

The past few pages have shown that during the "battle of the gauges" several remarkable engines were constructed simply to attain excessive speed, and to show what could be done on this or that gauge; some of these which worked well experimentally were practically unsuitable for the ordinary traffic.

The folly of this policy having at last made itself apparent, "the battle of the gauges" ended, and the various locomotive builders settled down to the construction of good useful engines, capable of working the ordinary trains of that period. Each builder or designer adopted a standard pattern of passenger engine, and although they were very similar in general design the special features of each were most marked; and even at the present day, no matter how much one of these old engines has been rebuilt, the original maker can be clearly determined by an examination of those parts which were made a speciality.

In 1849, Messrs. E. B. Wilson and Co., of Leeds, brought out a class in which there was an outside frame and outside bearings for the leading and trailing wheels, but inside bearings only for the driving axle: the first of these was named "Jenny Lind" (Fig. 59), and had cylinders 15 by 20 and wheels 6 feet diameter. Large numbers of these engines were built for the Midland and other railways.

Mr. Ross Winans, in 1849, constructed a celebrated engine at his Locomotive Works, Baltimore, for the Baltimore and Ohio Railroad. It had a four-wheeled leading bogie, a single pair of driving wheels 7 feet diameter, and a trailing bogie; the cylinders were placed outside. This engine was named the "Charles Carroll of Carrollton." It worked satisfactorily and

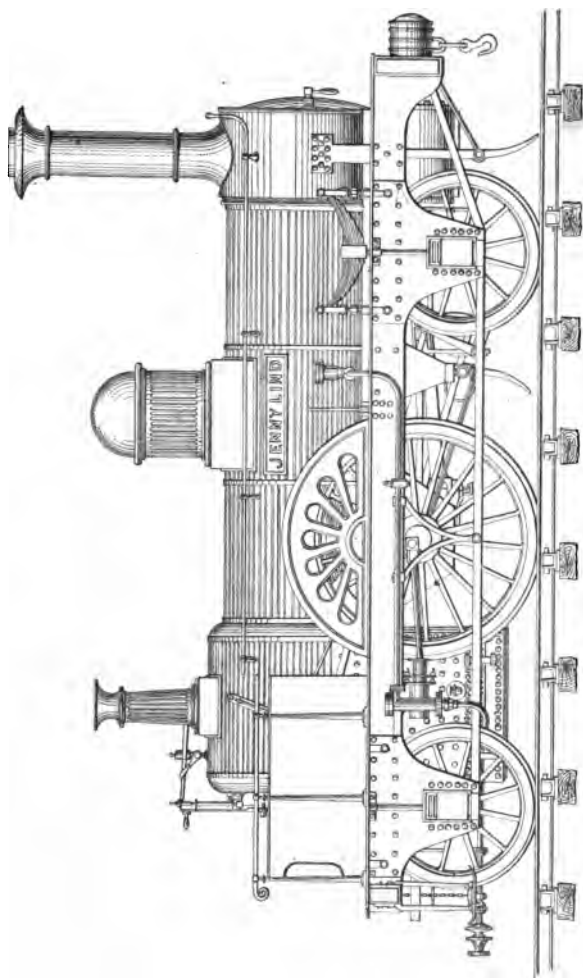


Fig. 59.—E. B. Wilson's Standard Pattern, 1849.

ran at very high speed, but it proved too heavy for the very light track over which it had to run.

At the same date, 1849, Messrs. E. B. Wilson & Co., of Leeds, built a trial engine for Mr. Crampton, in which he employed four large driving wheels of 6 feet 6 inches diameter, placed at a distance of 16 feet between centres. By means of outside coupling rods motion was communicated from the intermediate shaft to the four driving wheels. This engine weighed 32 tons, or 8 tons upon each wheel, which proved too much for the permanent way of that period. This engine was tried by Mr. Crampton upon the Midland Railway, and attained a speed of fully 75 miles an hour. It was also tried on other lines, but no railway company would purchase it on account of its great weight. Another engine of similar design was built, but much lighter. It ran upon the York, Newcastle, and Berwick for some years.

Messrs. Sharp Brothers, in 1849, built ten passenger engines for the Midland Railway, Nos. 60 to 69. The first six of these had cylinders 16×20 , and driving wheels 5 feet 6 inches diameter for the ordinary gauge. The Midland Company, having purchased the Bristol and Gloucester Company's line, required some broad-gauge engines to work thereon. Four of the engines by Sharp were therefore built "convertible"; they were, in fact, narrow-gauge locomotives having very long axles, and the wheels were placed quite outside the axle-boxes. The cylinders were 16×20 , driving wheels 6 feet 6 inches. Some years later, when the Midland Company removed the broad gauge between Bristol and Gloucester, the axles were shortened and the wheels placed between the double frames in the ordinary way.

Mr. J. E. McConnell, in 1844—5, designed and con-

structed at Bromsgrove some engines for the Birmingham and Gloucester Railway Company, in which he employed inside frames and inside bearings only. These small engines proved so satisfactory, that when he became locomotive superintendent of the southern division of the London and North-Western Railway, he retained the same design and built a large number of engines at Wolverton of the well-known "Bloomer" type. Some of these had cylinders 16×22 and

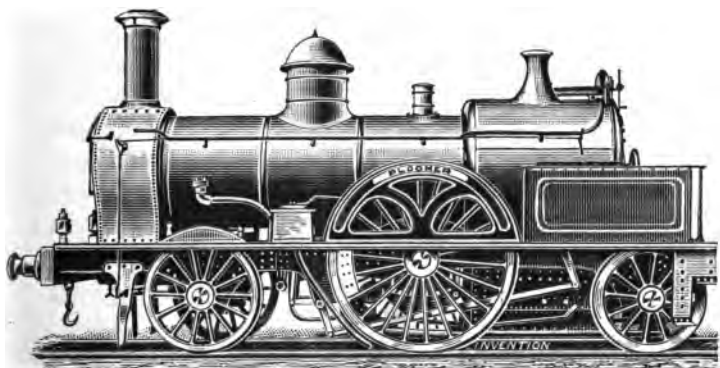


Fig. 60.—"Bloomer," Class 1850, L. & N.W.R., Southern Division.

6 feet 6 inches wheels—others similar to Fig. 60 had 7-foot wheels.

In November, 1852, Messrs. Fairbairn & Sons constructed a still larger engine from Mr. McConnell's design, for the southern division of the London and North-Western Railway, No. 300, having cylinders 18×24 , and driving wheels 7 feet 6 inches, the boiler being provided with his system of combustion chamber. This engine had double frames, and all the axles had *outside* axle-boxes, and weighed 31 tons.

Mr. McConnell also employed his patent design of boiler for the Wolverton goods engines, and placed all the six-coupled wheels under the barrel of the boiler.

It will have been observed that locomotive engineers for years had tried their utmost to obtain a large driving-wheel and a low centre of gravity. Mr. McConnell, however, disagreed most strongly with the "low boiler" theory, and maintained that a high boiler was no objection, and that engines having the highest boilers could run with the greatest steadiness. At that time his opinion was simply laughed at, now we see that he was correct, and only had the misfortune to be about thirty years in advance of his time.

During the year 1853, the London and North-Western Company employed Messrs. Woods and Marshall to test the efficiency of the Crewe and Wolverton engines (see Figs. 55 and 60), the result being that both were continued. It was strange that one company should continue to employ two locomotive superintendents and construct such different patterns of engines.

During the early part of the year 1852, Messrs. R. Stephenson and Co. constructed six express engines for the Midland Railway, having double frames, inside cylinders 16 by 22, and driving-wheels 6 feet 6 inches; they were numbered 130 to 135 inclusive. One of these remained in use till 1892, and in 1853 Messrs. Sharp, Stewart & Co. built ten express engines for the same line having cylinders 16 \times 22, and a single pair of 6 feet 6 inch driving-wheels, Nos. 120 to 129.

Mr. Archibald Sturrock, locomotive superintendent of the Great Northern Railway, in 1853 designed, and

Messrs. R. & W. Hawthorn built, a large express engine for that line, No. 215. This engine ran upon eight wheels, four in a group, but not in a bogie, a single pair of driving-wheels 7 feet 6 inches diameter, and a pair of trailing wheels. The cylinders were inside, 17 × 24, and the engine had double frames. This engine appears to have been broken up about 1870, for at that date a new engine, No. 92, was built, having the old 7 feet 6 inch wheels, cylinders, and some other parts from old 215. No. 92 is still at work.

Mr. Pearson, the locomotive superintendent of the Bristol and Exeter Railway, and a very strong advocate of the broad gauge, "could not rest to think the narrow-gauge "Cornwall" (Fig. 56) had the largest wheel and attained the greatest speed." He therefore designed, and Messrs. Rothwell and Co., of the Union Foundry, Bolton, constructed, a class of broad-gauge tank engine in 1853 which ran upon 10 wheels, namely, a leading bogie, a single pair of driving-wheels 9 feet diameter, and a trailing bogie; the cylinders were $16\frac{1}{2} \times 24$, the driving-wheels were without flanges. The driving-axle was placed above the framing. The boiler contained 180 tubes of $1\frac{1}{8}$ inch diameter; the total weight of the engine in working order was 42 tons. The author remembers that at a speed of about 60 miles an hour the engine was remarkable for its very easy riding. American engineers have always maintained that these double bogie engines were a larger repetition of the Winans "Carroll" of 1849.

Mr. Pearson many years ago informed the writer that his engines had been officially tested at 81 miles an hour, and that the average consumption of

coke over a distance of 100,000 miles was only $21\frac{3}{4}$ lbs. per mile.

This maximum speed of 81 miles an hour was attained thirty-nine years ago, but it still remains the highest on record. In the year 1876 one of this class of engine ran off the line at Long Ashton, after which the driving-wheels were all reduced to eight feet and tenders were added. A few of these celebrated engines as altered were running until May, 1892.

In 1855 Mr. Gooch placed a new class of engine upon the Great Western Railway which had been constructed from his designs by Messrs. R. Stephenson; these engines were intended to be to some extent coupled "Great Westerns," being designed on the same general principles, but they had two pairs of 7 feet driving-wheels instead of one pair of 8 feet wheels. These were the largest driving-wheels ever coupled at that time. Only ten of these engines were built, and after running an average distance of about 500,000 miles each, it was not considered expedient to rebuild them.

Between the years 1853 and 1860 very much attention was given to the subject of burning coal instead of coke in locomotives. Messrs. Beattie, McConnell, Cudworth, and others, constructed most complicated fire-boxes and boilers having mid-feathers, combustion-chambers, or special forms of "grate."

All these proved perfectly unnecessary, for it was found by experiment on the Midland Railway that a brick-arch placed in the ordinary fire-box below the tubes; a deflector or baffle-plate within the door; a fire-door by which the supply of cold air can be properly regulated, and a steam-jet or blower in the

chimney, were all that were required to effectually consume the smoke in a locomotive.

At this period of locomotive history reference must be made to the works of a well-known engineer, who in times past took, and who still takes, an important part in the work. The Manchester and Birmingham Railway (or, more correctly, the line from Manchester to Crewe) had its locomotive department at Longsight, near Manchester, and as far back as May, 1842, Mr. John Ramsbottom was appointed as locomotive superintendent of that company. Upon the amalgamation, in 1846, he continued to hold the same position under the name of district superintendent of the north-eastern division of the London and North-Western Railway; and on August 1, 1857, we find him taking charge, as locomotive superintendent, of the northern division of the North-Western Railway, at Crewe works, in succession to Mr. Trevithick.

In the autumn of 1858, Mr. Ramsbottom turned out at the Crewe works a number of his new goods engines, having inside frames and inside bearings only, inside cylinders 17 inches by 24 inches, and six coupled wheels of 5 feet diameter; and in the following year, November, 1859, he placed his first express engine (Fig. 61) upon the northern division; it was named "Problem," and is still at work.

The "Problem" type, of which sixty were built between the years 1859 and 1865, all of which are still running, had cylinders 16 inches by 24 inches.

Diameter of driving-wheels (new)	7 ft. 7½ ins.
--	---------------

Weight of engine in working order.. .. .	27 tons.
--	----------

Weight of tender in working order.. .. .	17½ tons.
--	-----------

Total	44½ tons.
---------------	-----------

"Problem" was also the first engine in this country fitted with Giffard's injector for feeding the boiler.* An engine of this class, named "The Lady of the Lake," was sent, when quite new, to the Exhibition of 1862, and was awarded the bronze medal, which it still carries. Mr. Ramsbottom also received a medal for his system of troughs between the rails, by which engines could, and do, pick up water when running.

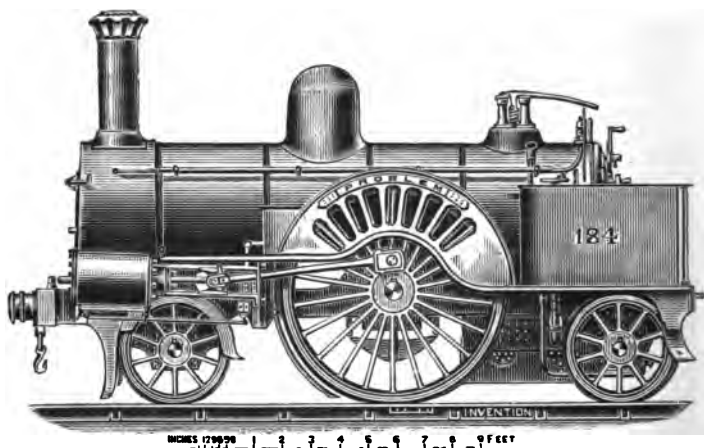


Fig. 61.—"Problem," London and North-Western Railway, Northern Division, November, 1859.

This latter appliance proved of considerable value on January 5th, 1862, when an exceptionally fine and important run was made from Holyhead to Euston, the occasion being when answers were brought to the despatches sent by the English Government to Washington, requiring the immediate surrender of Messrs. Mason and Slidell, who had been taken off an English ship, the *Trent*. An engine of the "Problem"

* For particulars as to the injector, see p. 192.

type (Fig. 61), by means of the water-trough, ran from Holyhead to Stafford, $130\frac{1}{2}$ miles, without stopping, and occupied only 145 minutes, and another engine went forward to London; the whole distance, 264 miles, being performed in five hours, with only one stop; and on certain favourable parts of the line several miles were run at a rate of "just under, if not quite, 80 miles an hour."

It is also a fact worthy of note that in the great railway race of 1888, when it was required to run through without stopping, at the highest speed, from London to Crewe, the old engines of the "Problem" type, namely, "Waverley" and "Marmion," ran the racing trains. All the sixty engines of the class are now from 27 to 33 years old, but with a light load in proportion to their power they are at the present day capable of running as fast as any locomotive now at work on any railway in this country.

Mr. McConnell, at Wolverton, in 1861, constructed three very large engines of the "Bloomer" type, named "Delamere," "Caithness," and "Maberley," one of which, No. 373, engaged much attention at the Exhibition of 1862; their chief dimensions being,

Diameter of cylinders	18 ins.
Length of stroke	24 ins.
Diameter of driving-wheels (new) .. .	7 ft. $7\frac{1}{2}$ ins.
Heating surface of fire-box	242·5 sq. ft.
Heating surface of tubes	980·3 sq. ft.

Total 1222·8 sq. ft.

The fire-box was constructed to burn coal, and had a combustion chamber.

Working pressure of steam	150 lb. per sq. in.
Height of centre line of boiler above the rails	7 ft. $5\frac{1}{2}$ ins.
Weight upon driving-wheels	14 tons.

Total weight of engine in working order	Tons, cwts.
Weight of tender loaded	34 14
	25 0
Total	59 14

From these details it will be seen that these three engines were very fine specimens, and that Mr. McConnell successfully solved the problem of large wheels, large inside cylinders, high steam pressure, and high boiler. He proved that a high boiler was no objection, and that engines having the highest boilers can run with the greatest steadiness; he also proved, in 1861, that with a light load these engines could under very favourable circumstances run "*within a fraction of 80 miles an hour.*" Towards the close of the year 1861 Mr. McConnell resigned, and Wolverton was closed as a locomotive building establishment, Mr. Ramsbottom, of Crewe, in the early part of the year 1862, being appointed locomotive superintendent of the whole line.

Messrs. Neilson & Co. constructed an express locomotive (Fig. 62) to send to the Exhibition of 1862; it was in every respect similar to those previously constructed by the Caledonian Railway Company; it had double frames, outside cylinders, and a single pair of 8 ft.-2 in. wheels, and was, in fact, a larger edition of the Grand Junction Company's locomotives, as constructed at Crewe works in 1843 by Mr. Allan.

Diameter of cylinders	17½ ins.
Length of stroke	24 ins.
Diameter of driving-wheels	8 ft. 2 ins.
Total heating surface	1,172 sq. ft.
Weight on driving-wheels	14 tons 11 cwt.

This locomotive was purchased by the late Pacha of Egypt, who required an engine "to take him at an average speed of 70 miles an hour." This engine, by Neilson, also those built by Mr. Benjamin Connor, were

officially tested at 80 miles an hour, and some still remain in use on the Caledonian at the present time. They are good engines, but the existing loads and the Beatlock incline have necessitated their removal from main line expresses.

Messrs. Stephenson & Co., in 1862, constructed a large passenger engine named "Saltburn" for the Stockton and Darlington Railway, having a leading bogie, four coupled wheels of 7 ft. diameter, the

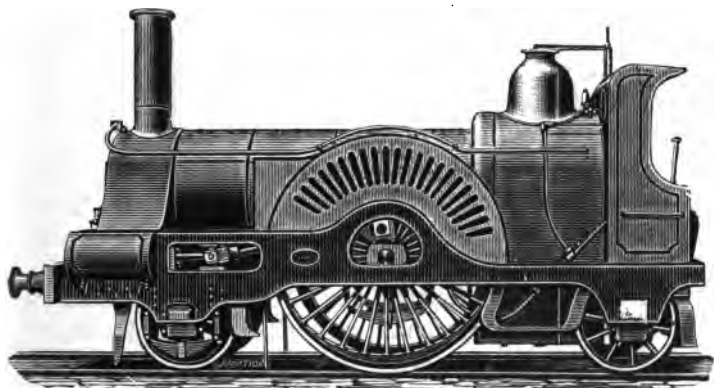


Fig. 62.—Express Engine, built by Neilson, 1862.

cylinders placed outside being 17×24 ; in this engine a small auxiliary tank was placed under the foot plate for heating the feed water by means of steam from the boiler.

About the year 1863 Mr. Sturrock introduced "steam tenders" upon the Great Northern Railway for the goods engines. These tenders had outside frames, six coupled wheels, and inside cylinders, steam being supplied from the engine boiler. The tender thus converted by Mr. Sturrock became practically a

second engine, having a water-tank in the place of a boiler. The cylinders were 12 inches diameter and 17 inches stroke, the cranked-axle being the middle one. The exhaust steam from the cylinders was discharged into a tubular condenser and heated the water in the tender tank. The weight of the tender empty was 18 tons, and loaded, 28 tons.

The steam tenders undoubtedly conveyed very heavy trains of coal, as the author saw when riding on one between Hitchin and London; and the Great Northern Company had about fifty in use, but they did not do the extra amount of work to pay for their cost, and practically they proved a great failure. Many of the tenders *without the steam apparatus* are still in use.

Mr. Matthew Kirtley, locomotive superintendent of the Midland Railway, in the early part of the year 1861 built several powerful tank engines to assist trains up the Lickey incline; these had double frames, six coupled wheels of 4 ft. diameter, and cylinders $16\frac{1}{2} \times 24$. They are still at work but renumbered.

Mr. Kirtley also, early in 1862, designed and constructed at Derby six powerful express engines to convey the anticipated heavy traffic to the exhibition of that year. These engines ran upon six wheels, the driving and trailing wheels being 6 feet 2 inches diameter, and coupled, the cylinders were $16\frac{1}{2}$ inches diameter, 24-inch stroke, and the steam pressure 140 lbs. per square inch; they were numbered 80 to 85 inclusive. On one occasion the writer rode from Leicester to King's Cross, London, upon one of these engines, when it drew 10 coaches, and on the return journey, with a much lighter load, a speed of 72 miles an hour was attained upon a falling gradient.

Previously to this date four-wheeled coupled engines

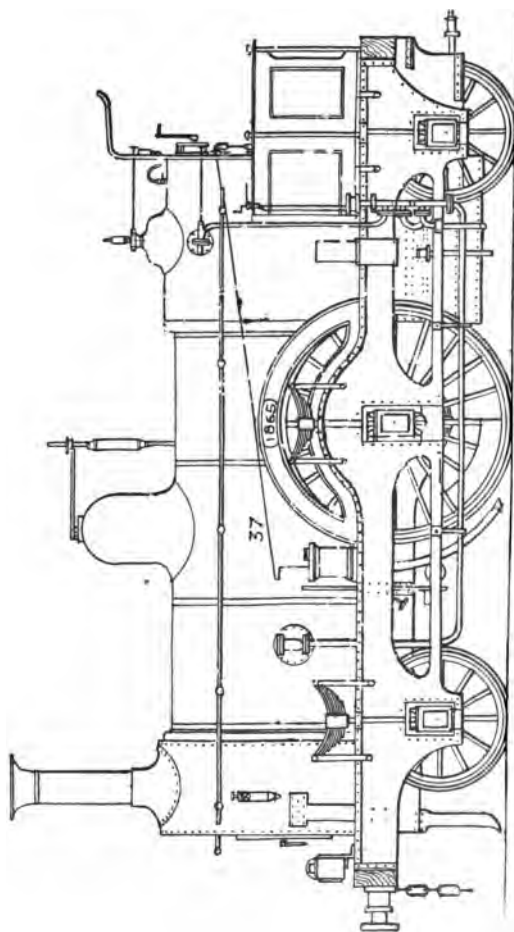


Fig. 63.—Kirtley's Express Engine, Midland Railway Company, 1864—5.

had been considered unsuitable for passenger traffic and high speed.

In 1864, Mr. Matthew Kirtley, the Midland Company's locomotive superintendent, decided to construct

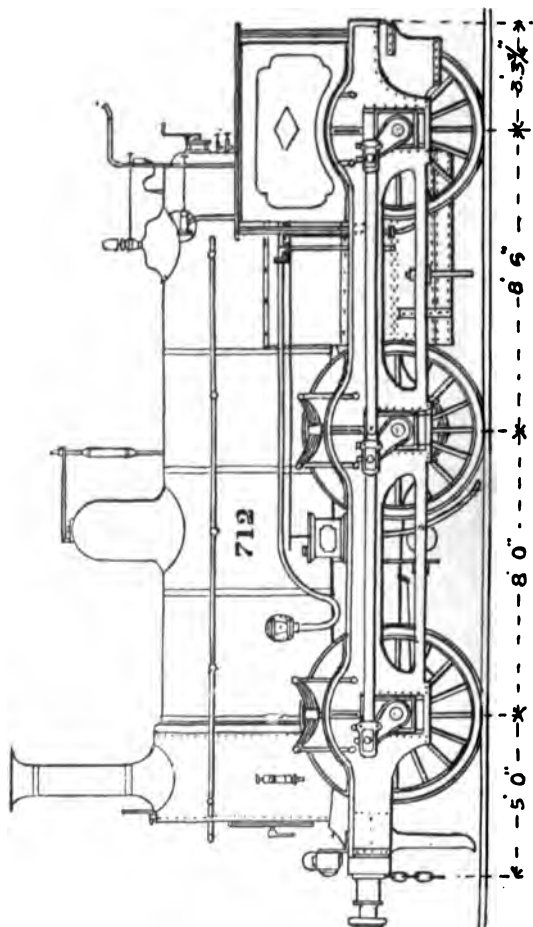


Fig. 64.—Kirtley's Goods Engine, Midland Railway Company, by Dübs & Co., 1869.

at the Derby Works 20 express engines, generally known as the "30 class," having cylinders $16\frac{1}{2} \times 22$,

and driving-wheels 6 feet 8 inches diameter (see Fig. 63).

These engines have been remarkable for the heavy work which they have performed, and for economy both in fuel and repairs.

With a load suitable to their power, they are still capable of running at the highest speeds, but of course they are not now sufficiently powerful for main line expresses.

From the formation of the Midland Railway Company in 1844 to the close of the year 1862, Mr. Kirt-

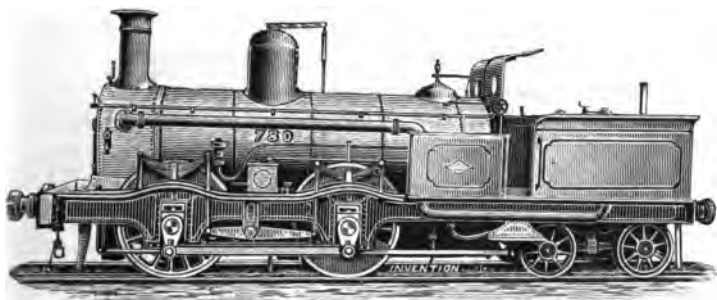


Fig. 65.—Tank Engine, No. 780, Midland Railway Company, 1870.

ley constructed the goods engines with cylinders 16 by 24, and 5 feet 2 inch wheels. From 1863 to 1869 he employed 16½ inch cylinders, and from 1869 to 1875, 17 inch cylinders (see Fig. 64).

For working the Midland Company's trains over the Metropolitan Railway, Mr. Kirtley designed, and Messrs. Dübs & Co. in 1870 constructed, twenty tank engines (Fig. 65) having cylinders 17 × 24, four coupled wheels 5 feet 2 inches diameter.

Mr. Kirtley also designed a powerful class of express

engine for the Midland Railway, of which forty-eight were built in 1870, thirty by Messrs. Neilson & Co., and eighteen at Derby, having cylinders 17×24 , and four coupled wheels of 6 feet 8 inches diameter; the tractive force which could be exerted for each pound of effective steam pressure per square inch upon the pistons being 86·7 lbs., or thus—

$$\frac{17 \times 17 \times 24}{80} = 86\cdot7 \text{ lbs.}$$

The distance between the centres of the two cylinders is 2 feet 6 inches; this has always been a very great advantage to these engines, on account of the extra width available for steam and exhaust passages.

The boiler and fire-box were of the standard pattern, previously used by Mr. Kirtley for his goods engines (Fig. 64). The boiler contained 168 brass tubes of 2 in. diameter outside, and was fed by one injector and one pump.

Heating surface of tubes	sq. ft.
Heating surface of fire-box	993
	103
Total	1096

Two safety valves were placed upon the dome, pressed to blow off at 140 pounds per square inch.

A Roscoe lubricator was also provided.

Surface or area of fire-grate, 17 square feet; wheel-base of engine, 16 feet 6 inches.

Weight in working order—

Of engine	tons	cwt.	qrs.
Of tender	35	18	2
	24	15	2
Total	60	14	0

These engines have been remarkable for their excel-

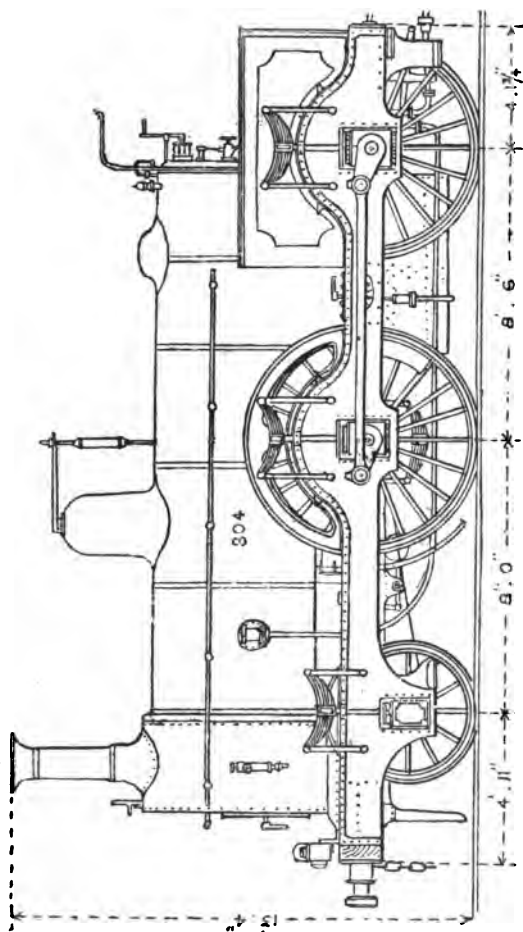


Fig. 66.--Midland Express Engine, "800 Class," 1870.

lent working, and since their cylinders have been en-

larged to 18 inches diameter, their efficiency has been still further increased.

The tender (Fig. 67) ran upon six wheels, and carried 2,000 gallons of water, and, if necessary, 4 tons of coal, and was provided with a hand brake applying a wooden block to each wheel.

In 1871, Mr. Kirtley introduced another type of ex-

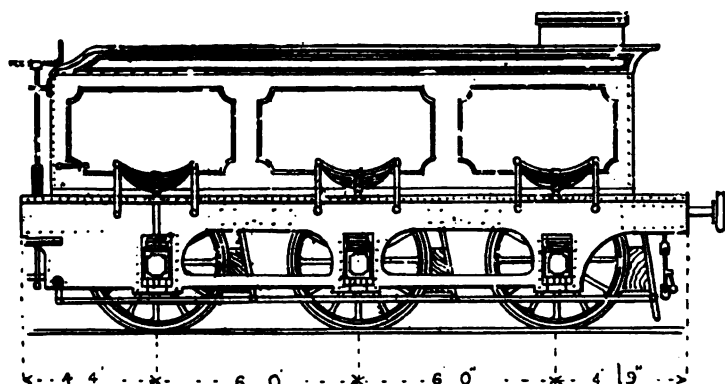


Fig. 67.—Midland Tender, 1870.

press engine on the Midland Railway, having inside bearings only for coupled wheels.

No. 890, the first of this class, had cylinders 17×24 and coupled wheels 6 feet 8 inches diameter. A very large number of engines of this type of framing have since been built and are all at work.

It will be observed that these engines had double frames, but the coupled wheels had inside bearings only; the chief dimensions being as follows:—

							ft.	in.
Diameter of cylinders	..	..	..	..	..	..	0	17
Length of stroke	..	..	..	..	..	..	0	24

Diameter of coupled wheels	ft.	in.
Number of tubes	6	8
Diameter of tubes	232	
Boiler pressure	0	1½
140 lbs. per square inch.		

Heating surface of fire-box	sq. ft.
Heating surface of tubes	92
	1,020

Total 1,112

Number of square inches of bearing surface on each pair of journals	} Leading	104·
		Driving
		Trailing
		129·

Weight of engine in average working order	tons	cwt.
„ tender „ „ „	36	14
	26	4

Total 62 18

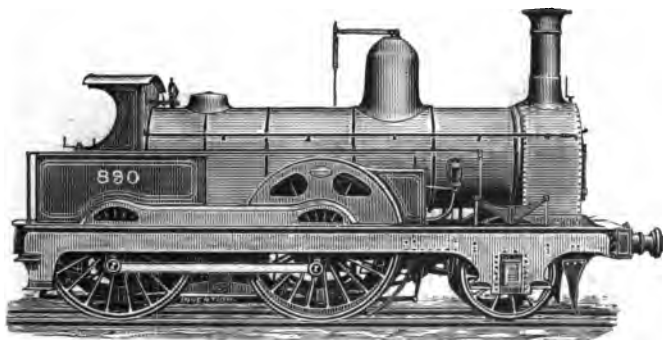


Fig. 68.—Kirtley's Express Engine, Midland Railway Company, 1871.

When the American Pullman car trains were first introduced into this country in 1874 engines of the 890 class were employed to work them, and were specially fitted with a central buffer at the back of the tender, as the cars had not side buffers.

CHAPTER IV.

MODERN LOCOMOTIVES FOR MAIN LINE TRAINS.

It being difficult to exactly define what is meant by "modern locomotives," for the purposes of this chapter engines will be included which have been designed and constructed within the past twenty years.

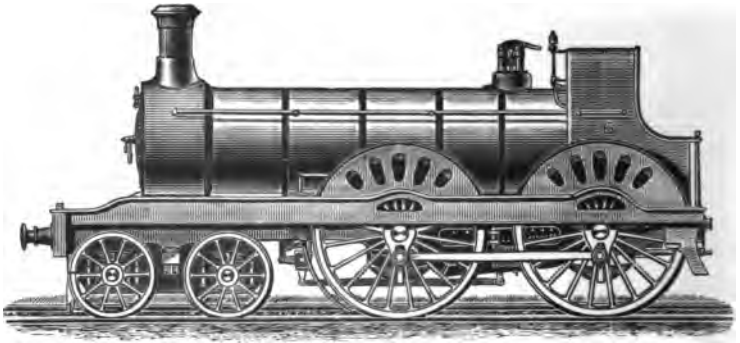


Fig. 69.—Glasgow and South-Western Express Engine, July, 1873.

Mr. James Stirling, locomotive superintendent of the Glasgow and South-Western Railway, at Kilmarnock, in 1873, was the first locomotive engineer to introduce a design or combination which included a leading-bogie, four coupled wheels 7 feet diameter, and inside cylinders 18 inches diameter.

The tractive force exerted for each pound of effective steam pressure per square inch in the cylinders being, therefore, —

$$\frac{18 \times 18 \times 26}{84} = 100.285.$$

It had been contended by many engineers that a pair of 18-inch cylinders with their valves between them could not be placed between the frames of an engine upon the 4 feet 8½ inch gauge, but Mr. Stirling proved that sufficient space existed by placing the cylinders thus in his new engine.

The boiler is flush-topped, having a Ramsbottom safety-valve placed over the fire-box casing, and is without a dome.

No. 6 (Fig. 69) was reversed by means of screw gear, but in May, 1874, Mr. Stirling completed a similar locomotive, No. 95, and it was the first to be fitted with his steam reversing gear. This gear consists of two small cylinders placed horizontally upon the right-hand side of the foot-plate, both the pistons being attached to one rod which passes out through the front cylinder cover and is connected to the rod working to the reversing gear. By means of a small handle the engine-driver can admit steam to either end of the steam cylinder, and thus put the engine in forward or backward gear at pleasure. Between the two cylinders the piston rod carries an index which works over a fixed scale showing the position of the gear and the proportion of the stroke at which the steam is being cut off in the main locomotive cylinders.

To retain the steam reversing gear in any required position the second small cylinder is completely filled

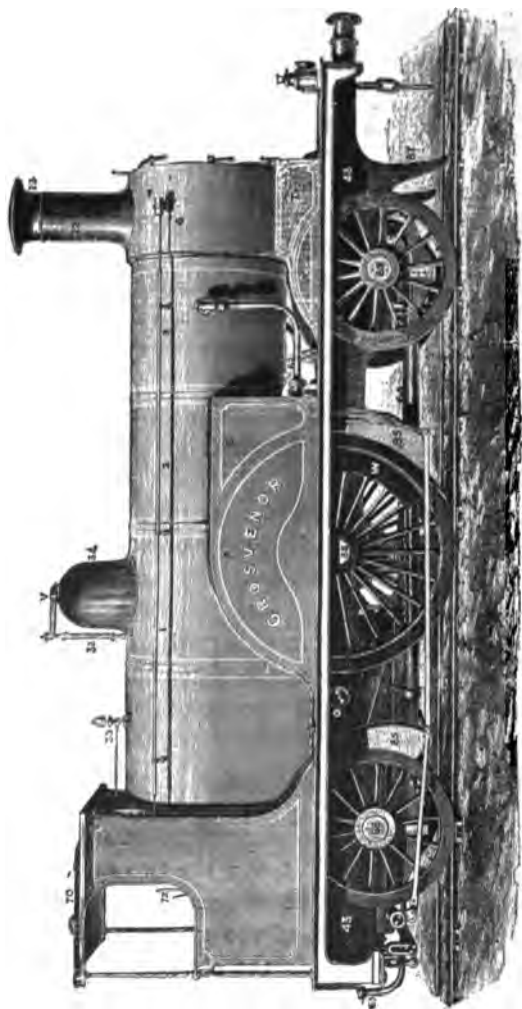


Fig. 70.—Brighton Company's Express Engine, 1874.

with oil, and its piston can only move when the driver permits a valve to open to allow the oil to pass from one end of the small cylinder to the other.

Therefore, without any manual labour the engineman can reverse the locomotive by means of a small handle upon the foot-plate, and as the one handle actuates both the steam valve and the oil valve, it follows that in whatever position the driver stops the supply of steam the oil will firmly hold the gear.

Engines of this type still remain the standard pattern upon the Glasgow and South-Western Railway, and Mr. Stirling has during recent years introduced a very similar design upon the South-Eastern Railway, but having cylinders 19 inches diameter, for working the express trains between Charing Cross and Dover.

In 1874 Mr. Stroudley designed and constructed at the Brighton Works an engine named the "Grosvenor," No. 151 (Fig. 70).

This engine has a single pair of driving wheels 6 feet 9 inches diameter, cylinders 17×24 , weight on driving-wheels 14 tons. The "Grosvenor," was sent with the Brighton Company's train to the Newark Brake trials in 1875; it also was the engine employed throughout Captain Galton's brake experiments in 1878—79.

When the "Grosvenor" was new the author rode several trips upon her foot-plate. On one of these 22 coaches were conveyed from London to Brighton by the five o'clock express without any loss of time.

Mr. S. W. Johnson, in 1875, introduced a powerful type of engine upon the Midland Railway for the conveyance of heavy mineral trains, No. 1448 (Fig. 71), being one of those built by Kitson & Co.

Engines of this class have cylinders $17\frac{1}{2} \times 26$, and

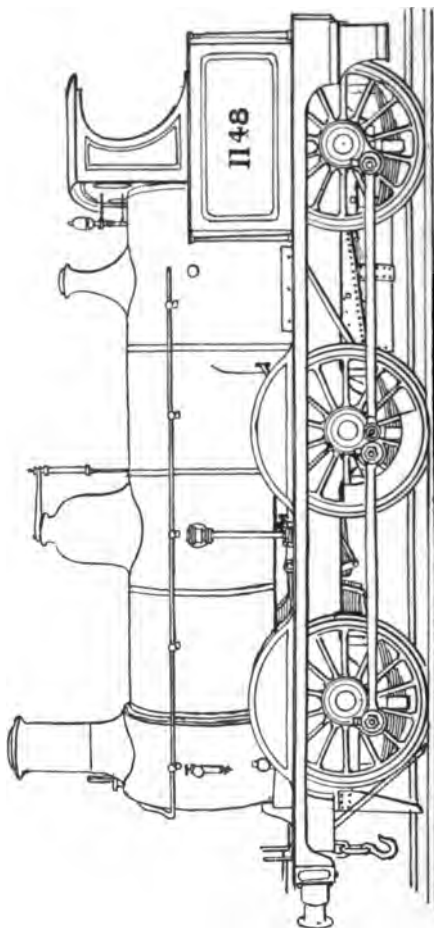


Fig. 71.—Midland Mineral Engine, 1875.

six coupled wheels of 4 feet 10 inches diameter; the

tractive force for each pound of effective pressure on the pistons being therefore—

$$\frac{17\frac{1}{2} \times 17\frac{1}{2} \times 26}{58} = 137.284.$$

Heating surface 1,225 square feet.

In 1878 Mr. F. W. Webb, of the London and North-Western Railway, converted one of the old engines on that line into a compound, on Mr. Mallet's system, the result of its working being that Mr. Webb in 1881-2 built at Crewe a compound engine of his own design named "Experiment," No. 66.

Mr. Webb's system employs three cylinders, namely two high-pressure cylinders of equal size, placed outside and arranged to drive the hind driving-axle, and one low-pressure cylinder placed inside, under the smoke-box, and arranged to drive the front driving-axle; the steam, of course, passing from the two high-pressure cylinders into the one low-pressure cylinder.

There is no subject relating to locomotive construction which has engaged so much attention and caused so much controversy as the introduction of "Compound" Express Engines. The advocates of the compound principle maintain that "as the steam is used twice over there must be a saving in fuel, and that even if some of the early engines built are not fully up to expectations the defects will be overcome in the next to be constructed."

On the other hand the advocates of the "Simple" system point out that two sets of cylinders and motion are cheaper to construct and cheaper to maintain than three sets; they hold the opinion that there is no

saving in coal, and that even if there were, it would be due to the high pressure of steam used, not to the compound principle; and with regard to the question of fast running they refer to the fact that at the time of the great railway race of 1888 the three-cylinder engines had to be withdrawn, and "simple two-cylinder" engines employed to perform the fast running.

The only possible way to prove what are the real capabilities of the "Simple" and "Compound" systems, respectively, is to have a complete and impartial trial. Let two engines be built, the one "Simple," the other "Compound"—the boilers, fire-boxes, heating surface, pressure of steam, and diameter of driving-wheels, being identical in each. Let the first cost, cost of maintenance, consumption of coal and oil, be carefully ascertained, and let the two engines be run over the same section of line with similar trains; in fact, have the trials made absolutely fair, and in a very short time the results would settle all the controversy.

The writer has watched the subject most carefully from the first, in an impartial spirit, but he cannot fail to observe that "facts" are in favour of the "Simple" engine. Whatever a "Compound" engine can do a "Simple" engine can do, and frequently with more efficiency. It is therefore not a matter of surprise that the locomotive superintendents of all the other important lines, after having made themselves fully acquainted with the "Compounds" in use in this country, continue to build large numbers of non-compound express engines, which give great satisfaction.

In 1881 the late Mr. William Stroudley, locomotive superintendent of the London, Brighton and South

Coast Railway, found that engines of increased power were required to work the Company's express trains, which were constantly increasing in weight; for instance, the 8.45 A.M. express from Brighton to London Bridge being a train often consisting of 25 coaches, the time allowed being 1 hour 10 minutes, the weight, including engine and tender, being fully 350 tons. The return train leaves London Bridge at 5 P.M., and arrives at Brighton at 6.5 P.M.

Mr. Stroudley, therefore, constructed in 1882, at the Brighton works, a powerful express engine named "Gladstone" (Fig. 72).

	ft.	in.
Diameter of cylinders (18½)	1	6½
Length of stroke (26)	2	2
Diameter of coupled wheels	6	6

The tractive force for each pound of effective pressure in the cylinders is therefore—

$$\frac{18\frac{1}{2} \times 18\frac{1}{2} \times 26}{78} = 111.020 \text{ lbs.}$$

Total heating surface	1,485	sq. ft.
Weight of engine in working order	38	tons. 14 cwt.
Tender loaded	27	7
Total	66	1

This engine is fitted with the Westinghouse automatic brake applying two cast-iron blocks to each of the coupled wheels, and one block to each tender wheel. The valves are actuated by the ordinary "Howe" curved link motion, the reversing being performed by the late Mr. Stroudley's arrangement, in which air from the Westinghouse brake is made to do the duty of a reversing lever or screw.

The position of the valves is under the cylinders,

therefore it follows that when steam is shut off, all friction between valves and their faces ceases. To reduce the wear of the leading wheels Mr. Stroudley arranged a pipe leading from the bottom of the exhaust, in order to turn a jet of steam against the flange of each leading wheel, the cold wheel condenses the steam and lubricates the flanges, and when running round sharp curves, especially in dry weather, the grinding noise of leading wheels, so often observed upon many lines, is consequently avoided.

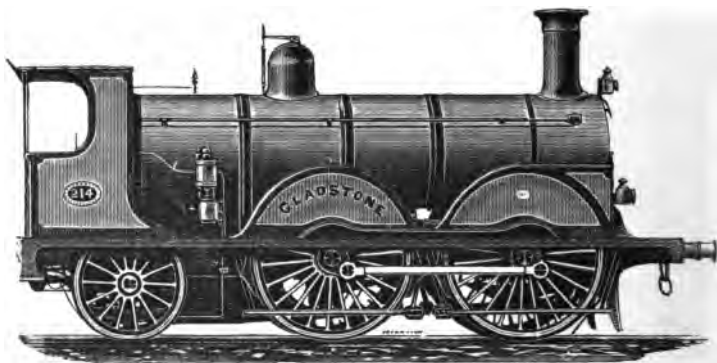


Fig. 72.—Brighton Company's Express Engine, 1882.

The tender runs upon six wheels, carries 2,250 gallons of water and two tons of coal, and has inside frame and inside bearings only.

A number of other similar engines have been built, one of which, named "Edward Blount," obtained a gold medal at the Paris Exhibition in 1889.

Engines of the "Gladstone" type have very successfully coped with the difficulty of conveying express trains of excessive length; however, in consequence of the increase of traffic and the generally-expressed wish of the passengers that "the journey from London to

Brighton should be performed in an hour," it is probable that at no distant date some of the heaviest trains will have to be run in duplicate.

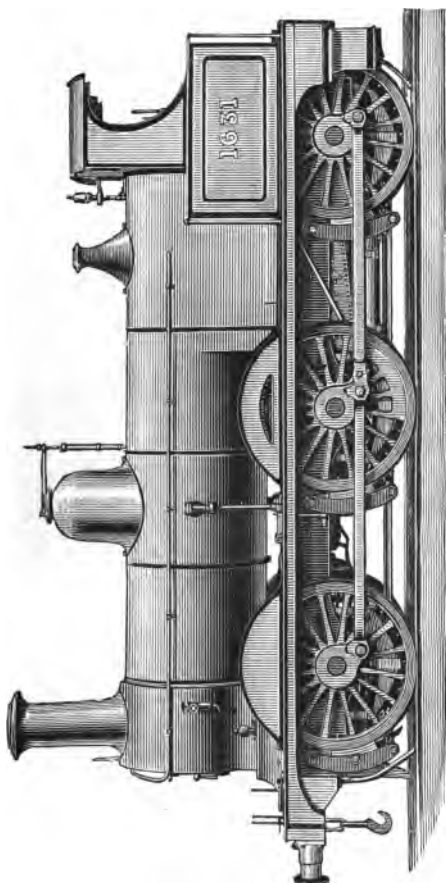


Fig. 73.—Modern Midland Goods Engine.

The line from London Bridge to Brighton is about $50\frac{1}{2}$ miles in length, and about three miles from London the New Cross incline of 1 in 100 for $2\frac{1}{2}$ miles com-

mences, after which the line rises and falls by gradients of 1 in 264 to three summits, one at Merstham tunnel, another at Balcombe tunnel, and the third at the Clayton tunnel. It therefore follows that with a train of fair average length, an engine having a "single" pair of driving wheels of 7 feet or 7 feet 6 inches diameter could, without difficulty, perform the journey of $50\frac{1}{2}$ miles in 60 minutes.

Fig. 72 shows that the "Gladstone" has the four large coupled wheels placed in front; this arrangement enables a very much shorter coupling-rod to be em-

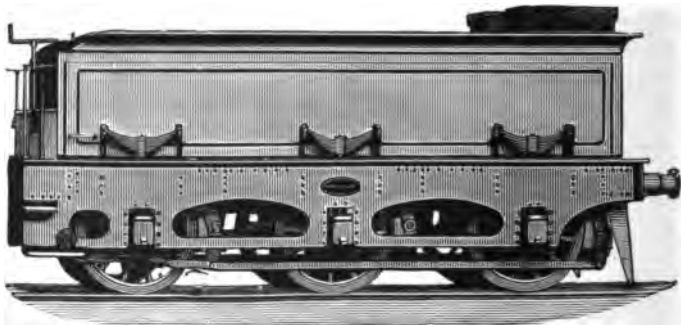


Fig. 74.—Midland Tender, No. 1631.

ployed, and leaves the length of the fire-box practically unlimited, which is not the case when the trailing wheels are coupled. However, for the fastest express work the writer would prefer an uncoupled wheel as leader.

The heavy express goods traffic upon the Midland Railway necessitates the employment of powerful locomotives. In 1877, Mr. Johnson introduced engines for this work having cylinders $17\frac{1}{2}$ by 26 inches, and wheels of 5 feet $2\frac{1}{2}$ inches diameter; his more recent

engines are of similar appearance, but have cylinders 18 by 26 inches, wheels 5 feet 2½ inches and a boiler pressure of 150 lbs. per square inch. Several hundreds of these engines are at work and giving good results.

The tender (Fig. 74) runs on six wheels, carries 2,200 gallons of water, and has a coal space of 144 cubic feet.

Mr. S. W. Johnson, the locomotive superintendent of the Midland Railway, introduced "bogie" express engines upon that line in 1876, and since that time 145 have been built of the same general design as Fig. 75, but with cylinders varying from 17½ to 19 inches diameter. Until 1885, the steam pressure employed was 140 lbs. per square inch, but in that year Mr. Johnson designed the 1738 to 1757 class, having steel boilers and a high pressure of 160 lbs. per square inch. Their dimensions being—

		ft.	in.
Diameter of cylinders	.. .. . (18)	1	6
Length of stroke	.. .. . (26)	2	2
Diameter of coupled wheels	.. .. .	7	0

The tractive force exerted for each pound of effective steam pressure per square inch in the cylinders being, therefore, thus—

$$\frac{18 \times 18 \times 26}{84} = 100.285.$$

As the steam pressure carried is 160 pounds per square inch, and the weight available for adhesion is over 28 tons, it follows that the engine is capable of performing fast and very heavy work.

		ft.	in.
Distance apart of cylinders from centre to centre		2	4
Length of boiler between tube plates	.. ..	10	10 ⁹ / ₁₆
Mean diameter of boiler inside	.. ..	4	1
Number of tubes	.. .. . 246		
Diameter of tubes	.. .. .	0	1½

Pressure of steam	160 lbs.
Total heating surface	1,261 sq. ft.

Weight in working order—

	tons.	cwts.	qrs.
On bogie wheels	14	12	1
On driving wheels	15	0	0
On trailing wheels	13	2	2
Total	42	14	3

Weight of tender, full, 3,250 gallons of water and 2 tons of coal	36	1	1
Grand total engine and tender	78	16	0



Fig. 75.—Midland Railway Express Engine, built 1885.

One of these engines, No. 1757, "Beatrice," was sent in 1887 to the Saltaire Exhibition, and has since been employed to work several royal trains.

For the purpose of working the Midland Company's trains over the Lancashire and Yorkshire Railway, *viâ* Hellifield, and thence to Carlisle, Mr. Johnson in 1888 designed the 1808 to 1822 class, similar to No. 1738, but with coupled wheels of only 6 feet 6 inches diameter.

The following is the complete list of the Midland Company's coupled bogie express engines, all of which are giving excellent results:—

Nos.	Builder.	Date.	Cylinder.	Stroke.	Coupled wheels.		Pressure of Steam.
			In.	In.	Ft.	In.	Lbs.
1312 to 1321	Kitson	{ 1876 }	17½	26	6	6	140
1327 to 1346	Dubs	{ 1877 }	18	26	7	0	140
1562 to 1581	M.R. Co.	{ 1882 }	18	26	6	9	140
1657 to 1666	M.R. Co.	{ 1883 }	18	26	6	9	140
1667 to 1676	M.R. Co.	1883	18	26	6	9	140
		1884	19	26	7	0	140
		{ 1885 }					
1738 to 1757	M.R. Co.	{ 1886 }	18	26	7	0	160
		{ 1887 }					
1808 to 1822	M.R. Co.	1888	18	26	6	6	160
11 and 14 }	M.R. Co.	1891	18	26	6	6	160
80 to 87 }							
2183 to 2202	Sharp }	1892	18½	26	7	0	160
	Stewart }						

The Caledonian Company's express engine No. 123 (Fig. 76), was constructed by Neilson & Co., and attracted much attention at the Edinburgh Exhibition of 1886, and during the "railway race" of 1888.

The following are the principal dimensions of the engine:—

Diameter of driving wheels	.. .. .	7 feet.
Diameter of cylinders	.. .. .	18 inches.
Length of stroke	.. .. .	26 inches.

The tractive force exerted for each pound of effective pressure per square inch in the cylinders being thus:—

$$\frac{18 \times 18 \times 26}{84} = 100.285 \text{ lbs.}$$

Working pressure of steam	.. .. .	150 lbs.
Weight on driving wheels	.. .. .	17 tons.

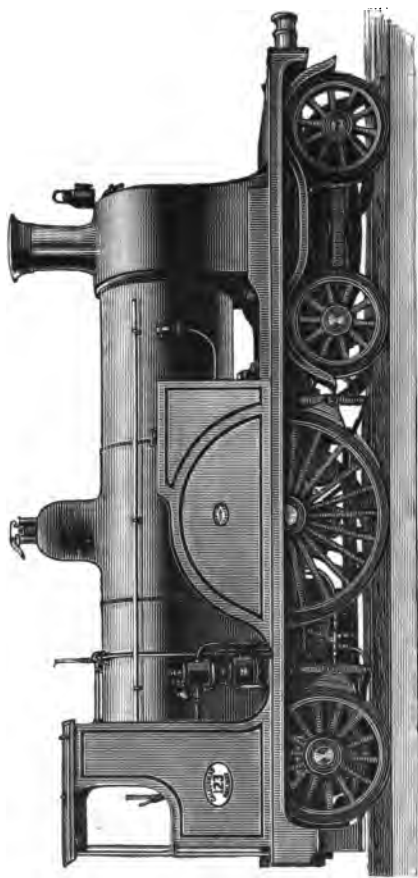


Fig. 76.—Caledonian Express Engine, No. 123, 1886.

Weight of engine in working order	.. .. .	tons.	cwts.
Tender loaded	.. .. .	41	18
		33	9
Total	.. .. .	75	7

The engine is provided with Adams' vortex blast-pipe, the Westinghouse automatic brake, a sand-blast, two injectors, and two water gauges.

No. 123, during the "railway race," worked the West Coast trains between Carlisle and Edinburgh.

The writer rode several trips in trains over this distance, and on one day timed the 101 miles covered in 104 minutes, some of the rising gradients being very severe, namely 1 in 75 on Beattock incline.

Number 123 was put into express traffic between Edinburgh and Carlisle on June 1, 1888.



Fig. 77.—Caledonian Tender, No. 123.

The average number of vehicles was seven, six of which were 8-wheeled carriages, each 42 feet long, and one a 6-wheeled brake van, giving a total train weight of about 146 tons, exclusive of engine and tender.

The average consumption of coal during the "racing" months of August, September and October, 1888, was 31.8 lbs. per engine mile.

The tender (Fig. 77) runs on 6 wheels, and carries 2,850 gallons of water, and has a coal space of 210

cubic feet. The tender brake can be applied by either Westinghouse apparatus or by the usual hand-screw. Wheel-base of engine and tender, 42 ft. 6 in.

Mr. Patrick Stirling, locomotive superintendent of the Great Northern Railway, having employed express engines with cylinders 17 by 24 inches, and a single pair of 7 feet wheels, decided to design a much more powerful type of express engine, having a larger driving-wheel and larger cylinders; and, as he could not employ inside cylinders, in consequence of the

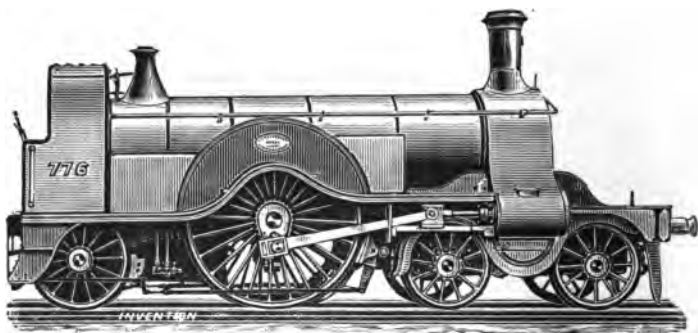


Fig. 78.—Type of Great Northern Express Engine, 1870 to 1887.

height of the cranks, he placed them outside, where he could get them between the wheels of the bogie, and in a horizontal line with the centre of the driving-wheel. The first of these was built in 1870, and forty-five of this pattern (Fig. 78) are now at work.

The particular engine illustrated was the "Jubilee" engine sent to the Newcastle Exhibition, 1887.

							ft.	ins.
Diameter of cylinders	..	..	..	..	..	..	0	18
Length of stroke	..	..	..	..	..	..	0	28
Diameter of driving wheels (nominal)	..	..	..	..	..	..	8	0

Therefore the tractive force exerted for each pound of effective steam pressure per inch in the cylinder is thus—

$$\frac{18 \times 18 \times 28}{96} = 94.5 \text{ lbs.}$$

Total heating surface 1,045 sq. ft.

Weight of engine in working order—

	tons.	cwts.
On front bogie wheels	8	2
On rear bogie wheels	9	9
On driving wheels	17	0
On trailing wheels	10	12
Total	45	3
Weight of tender loaded	33	7
Grand total, engine and tender	78	10

At the time of the “race,” engines of this type with loads of 7 to 9 coaches, weighing 120 to 140 tons, burnt only 22.6 lbs. of coal per mile, when working between London and Grantham, and Grantham and York. Nothing can more clearly show their economy in regard to fuel.

The line rises upon leaving London, King’s Cross, by gradients of 1 in 105 and 1 in 110 through Maiden Lane and Copenhagen tunnels, and from about the $4\frac{1}{2}$ mile post to the $12\frac{3}{4}$ post is all rising one in 200. It is found in practice that engines similar to Fig. 78 can take from 16 to 20 coaches up hill to Potter’s Bar at an average speed of 40 miles an hour, and then they can run the remaining 92 miles to Grantham without a stop at an average of just under, or if necessary, fully 60 miles an hour. In 1888 No. 776 took an important part in the “race to Edinburgh,” and

engines of this type have been timed at a speed of "just under, or practically, 80 miles an hour."

Since 1886 Mr. Stirling has placed several new express engines upon the Great Northern Railway, known as the 230 class, in which he has returned to the inside cylinder pattern. These have 6 wheels, cylinders $18\frac{1}{2} \times 26$, and driving wheels 7 feet $7\frac{1}{2}$ inches when new.

The practical result of working is that both types are very efficient. The inside cylinder class is less costly to build, the coal consumption is the same in both; and with reference to the question of speed it is found that the 7 feet 6 inch engines can run equally as fast as the 8 feet engines. For extremely fast running an *inside* cylinder engine is more suitable than an *outside*; it is therefore probable that in future the inside cylinder class will become the standard.

A special series of comparative trips recently made between Doncaster, York, and Peterborough, with a "compound" engine, and a Great Northern "simple" engine resulted considerably in favour of the latter.

For working the Great Eastern Company's heavy express trains between London, Yarmouth, Cromer, Doncaster, &c., Mr. James Holden has designed and constructed at Stratford several engines of the type illustrated (Fig. 79).

These engines have four wheels coupled, 7 feet diameter, the leading end being carried by a pair of 4 feet wheels.

The cylinders are 18 inches diameter, and the stroke 24 inches; the tractive force exerted for each pound of effective steam pressure per square inch on the pistons is thereforc—

$$\frac{18 \times 18 \times 24}{84} = 92.57.$$

The axle of the leading wheels is provided with both inside and outside axle-boxes.

Total heating surface	1,230 sq. ft.
Weight in working order	42 tons
Weight of tender	30 tons 12 cwts.
	<hr/>
	72 tons 12 cwts.

The boiler is 4 feet 3 inches diameter inside, butt jointed, the plates being of steel $\frac{1}{2}$ inch thick, and the working pressure of steam 150 lb. per square inch.



Fig. 79.—A Modern Great Eastern Express Engine.

The inside fire-box is of copper $\frac{1}{2}$ inch thick, except the tube plate, which is 1 inch thick at top and $\frac{1}{2}$ inch at the bottom. It is now the practice at Stratford to fit all engines having cylinders 17 inches diameter and upwards with $5\frac{1}{2}$ inches steam pipes and large regulators.

Indicator diagrams taken from the steam chest and cylinders show far less wire drawing at high speeds than formerly with the $4\frac{1}{4}$ -inch pipes.

The cylinders are cast in one, and placed with the

valve faces downwards. This arrangement allows of long axle bearings. The cylinders are well drained, and the valves can drop from the faces when running with steam shut off.

The valves are worked by the ordinary link-motion, counterbalanced by a spring and reversed by a wheel and screw. All engines now built at Stratford have single slide-bars, and cast-steel cross-heads, motion plates, spring hanger brackets, spring hangers, horn blocks, etc., and cast steel is now being introduced for all wheels. The coupling rods are made of wrought-iron of I section.

The tender is carried upon six cast-steel wheels of 4 feet diameter, the springs being outside the frames and (like all the new tenders) is now fitted with axle-boxes of a new pattern; the box is cast in one without keep, a large oil reservoir is arranged to slip in under the journal from the front, which is easily removed to change the oil pads as required; a dust shield is provided at the back or inner end of the box. These axle-boxes are found to work very satisfactorily, and there has not been any case of trouble from their heating. The tender carries 2,640 gallons of water and three tons of coal.

The whole of the passenger rolling stock upon the Great Eastern Railway, including, of course, engine 719, is fitted with the Westinghouse automatic continuous brake.

The express trains upon the Great Eastern Railway are heavy, more especially so during the summer months, when they are made up at Liverpool Street Station from 18 to 21, and sometimes even more, 6-wheeled carriages, the majority of which are third-

class six compartment vehicles, all fully loaded and drawn by one engine. The work which has to be performed by such engines is very greatly increased, as the writer observed when travelling with the trains, by the fact that at a distance of about half a mile from the starting point the Bethnal Green incline commences and continues for nearly three-quarters of a mile upon a gradient of 1 in 70; the gradients on both the company's main lines are severe, the curves both numerous and sharp, and the trains long.

In 1888 Mr. Holden designed a new type of express engines somewhat similar in appearance to 719, but having a "single" pair of 7 feet driving-wheels; these are also giving great satisfaction.

The Great Eastern Company has several locomotives at work fitted with Mr. Holden's system for burning liquid fuel. One of these, "Petrolea" (No. 760), is fitted to burn liquid fuel, but beyond the addition of an oil tank on the tender, and a few pipes leading to the liquid fuel injectors below the fire-hole door, there is nothing in its outward appearance to distinguish it from a coal-burning locomotive, to which it can be converted at any moment, there being no alteration in the construction of the fire-box. A special feature of the injector is an outer ring through which jets of steam pass, these jets impinging at the nozzle on the liquid fuel induced through a central cone, and breaking the fuel up into a very finely divided spray which ignites immediately. There is a passage in the injector through which air also is induced, and as the emission of steam, liquid, and air can be adjusted independently of each other, combustion is regulated to a nicety, and the slightest smoke

avoided. The fire is lit up with coal in the usual way, and a bed of incandescent fuel and chalk or broken bricks kept up, the weight of coal used in conjunction with the liquid fuel being about one-third of the total fuel consumed. The saving of labour to the fireman is, of course, very great, whilst the incandescent base enables the engine to lie practically inert for hours if required, yet ready to start into action directly the injector is worked. The "Petrolea" is employed to work some of the fastest and most important of the Company's trains, and the "fuel experiment" is being watched with great interest.

The Manchester, Sheffield, and Lincolnshire Company has recently constructed a new class of engine (Fig. 80), at its Gorton works, from the designs of Mr. Parker, locomotive superintendent.

These engines work the main line trains between Manchester, Retford, and Grantham. They have cylinders 18×26 , coupled wheels 6 ft. 9 in. diameter, with pressure of steam 160 pounds. Total heating-surface, 1,278 square feet. The tractive force for each pound of effective pressure is 104 lbs. The piston speed when running at 60 miles an hour is thus—

$$\frac{26 \times 60 \times 56}{81} = 1,076 \text{ feet per minute.}$$

Weight of engine in working order	..	..	46 tons.
Tender in working order	..	..	35 tons.
Total	..	..	81 tons.

The tender carries 3,080 gallons of water and 4 tons of coal, and is provided with a special design of axle-box which is easily accessible.

The main line of the Manchester, Sheffield, and Lincolnshire Company forms a very considerable link in the through route between Manchester (London Road) and London (King's Cross); and to avoid an extra stop at Retford, the Sheffield Company's engines work these express trains over the Great Northern Railway as far south as Grantham, and it is upon this important service that No. 564 and its sister engines are employed.

The loads vary from 120 to 200 tons, equivalent to

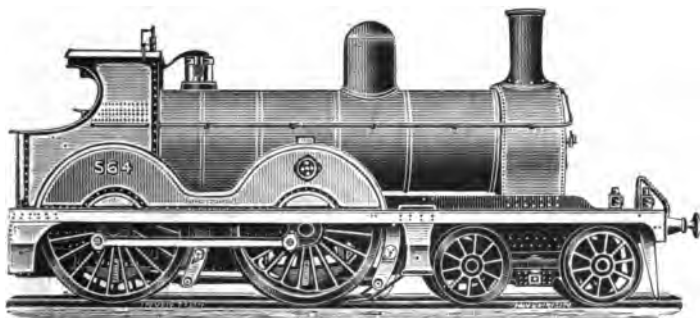


Fig. 80. —The Latest Design of M. S. & L. Express Engine.

nine to fifteen vehicles. The average speed, exclusive of stoppages, equals $44\frac{1}{2}$ miles an hour.

In order to fully appreciate the work which has to be performed, it is necessary to take into account the heavy gradients and also the very numerous curves which exist (the sharpest of which has a 7-chain radius), and which, of course, cause much extra flange friction. The writer has recently made several trips in trains over the route in order to carefully note the actual working of the engines upon the various gradients.

Leaving Manchester, the engine has one continuous up-hill pull of 22 miles to Dunford Bridge, the gradients being chiefly 1 in 100, 108, 97, 100, 177, 201.

Upon the return journey, after leaving Sheffield, the train has to climb up to Dunford Bridge, 19 miles of 1 in 132, 120, 131, 100, 135. Railway-men will see at a glance the work which these gradients imply, more especially when the long incline has to be faced after the engine has worked from Grantham to Sheffield, a distance of 56 miles, and made a start from that station.

The average consumption of coal per mile of the 564 type has been reduced to 24 lbs., and under favourable circumstances to $22\frac{1}{2}$ lbs., per mile.

At the present time the Manchester, Sheffield, and Lincolnshire line may be regarded as an extensive local system, its engines working from Liverpool on the west to Grimsby on the east, as far north as Scarborough, and south to Grantham. By a recent Act of Parliament, the company's system is being extended to Nottingham, and by means of a projected line through Leicester to Aylesbury it is now certain that at no distant date the Manchester, Sheffield, and Lincolnshire line will, in connection with the Metropolitan, become a great through route upon which its own engines will work trains to London.

The North Eastern Company exercises its running powers over the North British Railway between Berwick and Edinburgh, and provides the locomotive power for the through East Coast Joint Stock expresses between York and Edinburgh. For several years this service was worked by engines designed by Mr. Fletcher in 1870, having four coupled 7 feet

wheels and cylinders 17 by 24. In 1885 twenty express engines were built at the suggestion of Mr. Tennant, General Manager; these had 4 coupled 7-foot wheels, cylinders 18 by 24, and 1,250 square feet of heating surface; these proved remarkably fine engines, and still work the express trains between Newcastle and York.

In the early part of the year 1889 Mr. T. W. Worsdell, having become the Company's locomotive superintendent, made a new departure by constructing an engine—No. 1329—having a single pair of driving wheels 7 feet $1\frac{1}{2}$ inches diameter, and upon the compound principle. The working results of this engine proved thoroughly satisfactory to Mr. Worsdell; he therefore decided to construct five others of a still larger design, one of these being No. 1518 (Fig. 81).

Mr. T. W. Worsdell has laboured very energetically in the development of the "two-cylinder compound engine" (Fig. 81), which he maintains is better than the three-cylinder system.

The North-Eastern compound engines are worked upon the system of Messrs. Worsdell and Von Borries; the latest design (Fig. 81) has a high-pressure cylinder 20 inches diameter, and a low-pressure cylinder 28 inches diameter, the stroke in both cases being 24 inches. To place two such large cylinders between the frames it was found necessary to fix them at different levels, so that their axes are not parallel.

The driving-wheels are 7 feet $7\frac{1}{2}$ inches diameter.

The valves are worked by the Joy gear, through the medium of rocking shafts. There is also a special valve arrangement by which high-pressure steam can be admitted direct to the low-pressure cylinder. This

arrangement enables the engine to be started when the high-pressure cylinder is upon a dead point. The boilers have been built to carry a working pressure of steam of 200 pounds per square inch, but at the present time 175 pounds is the pressure used.

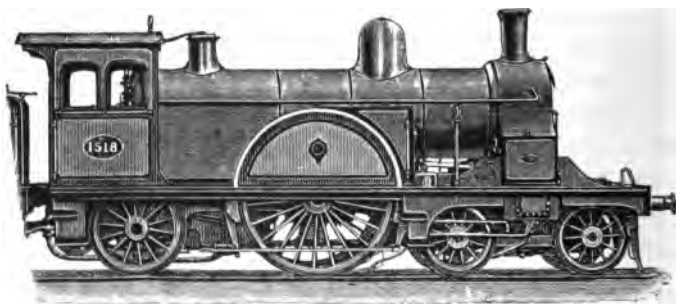


Fig. 81.—The Latest Design of North Eastern Engine.

Total heating surface....	..	..	..	1,139 sq. ft.
Weight on driving wheels	..	..	..	17 tons, 15 cwt.

	tons.	cwts.	qrs.
Weight of engine (full) ..	..	..	..
Weight of tender (full) ..	..	..	..
Total ..	86	14	2

The weight of 17 tons 15 cwts. upon the driving-wheels, assisted by the sand-blast, is found amply sufficient to provide the necessary adhesion.

This is the heaviest class of engine and tender complete running in this country.

The tender carries 4 tons of coal and 3,940 gallons of water, which enables these engines to run through from Newcastle to Edinburgh, 124 miles 31 chains, without a stop.

Several of these engines have run at very high speed,

and the writer has timed them at just under 80 miles an hour.

No. 1,517 was put into traffic between Newcastle and Edinburgh early in October, 1889. The loads varied from ten to twenty-two vehicles. At the end of October the average coal consumption was stated to be 26·4 lbs. per mile. On one occasion a trial was made between Newcastle and Berwick with a train of thirty-two empty carriages; the distance—67 miles—was run in 78 minutes, or three minutes under the time of the Scotch Express, and this with a load of certainly not less than 270 tons, exclusive of engine and tender.

Mr. Worsdell has also conferred a boon upon the drivers and firemen of the North-Eastern Railway, by providing them with a good comfortable cab, as shown (Fig. 81).

A similar engine, No. 1,521, was sent to the Edinburgh Exhibition of 1890.

Mr. William Adams, locomotive superintendent of the London and South-Western Railway, has lately designed and constructed, at Nine Elms, twenty express engines (Fig. 82) of great size and power.

Diameter of cylinders	19 ins.
Length of stroke	26 ins.

The piston-rod passes through the front cover of the cylinder.

	ft.	ins.
Diameter of bogie wheels	3	9½
Diameter of coupled wheels	7	1
Length of boiler barrel	11	0
Length between tube-plates	11	4
Diameter of boiler outside	4	4
Number of tubes	240	
Diameter of tubes outside	0	1½

The boiler is made of mild steel plates. Working pressure of steam, 175 lb. per sq. in.

The boiler is fed by two No. 8 injectors.

From rails to centre of boiler	7	9
--	---	---

Heating surface of tubes	1,245·60	sq. ft.
Heating surface of fire-box	122·16	„
Total	1,367·76	„
Area of fire-grate	18	„
From front of buffer plate to centre of bogie ..	8	ft 4½ ins.
From bogie centre to centre of driving-axle ..	10	9
From driving to trailing	8	6
From trailing axle to back of frame	4	3

The frames are of mild steel, placed inside, and the axles have inside-bearings only; the driving and trailing springs are attached to a compensating beam;

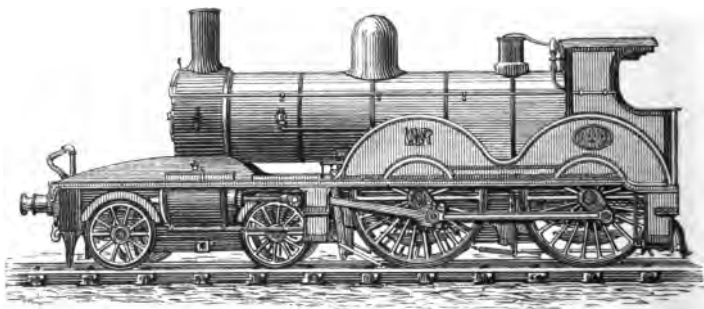


Fig. 82.—The Latest Design of London & South-Western Express Engine, No. 580.

the axles are of cast-steel; the tires of steel; copper fire-box and brass tubes; the coupling-rods are of wrought-iron of I. section.

The tender runs on six wheels of 3 ft. 9½ ins. diameter, the capacity of the tank being 3,300 gallons.

Weight of engine in working order—

ENGINE—

					Tons.	cwt.	qrs.
On bogie wheels .. ..	..	..	..	..	18	4	0
On driving wheels .. ..	..	..	..	..	15	13	0
On trailing wheels .. ..	..	..	..	..	14	18	0
Total engine .. ..	..	..	..	..	48	15	0

TENDER—

					Tons.	cwt.	qrs.
On first pair of wheels	..	..	..	..	9	18	0
On middle	..	..	..	..	10	8	0
On third	..	..	..	..	11	14	0
					<hr/>		
Total	..	..	..	..	32	0	0
Total engine and tender in working order	..	..	..	..	80	15	0
					<hr/>		
Total wheel-base of engine and tender	..	..	..	..	..	ft. 44	in. 3 $\frac{1}{2}$
Total length over buffers	..	..	..	..	..	53	8 $\frac{1}{2}$

One cast-iron brake-block is fitted to each coupled and tender wheel applied by "steam"; the engine is also provided with the necessary apparatus for working the automatic vacuum brake upon the train.

Mr. Adams has also designed and constructed another type of locomotive for either passenger or goods traffic, these new engines being employed to run express goods between London and Exeter, and also upon heavy excursion traffic.

They are tender engines running upon six wheels, having four coupled wheels in front and a small pair of trailing wheels under the foot-plate.

"530 CLASS."

Diameter of cylinders	..	..	..	..	18 ins.
Length of stroke	..	..	..	..	26 "
Diameter of coupled wheels	..	..	..	..	6 ft.
Length of boiler barrel	..	..	..	..	11 "
Number of tubes	..	..	..	..	218
Diameter of tubes (outside)	..	..	..	..	1 $\frac{1}{2}$ in.
Heating surface of tubes..	..	..	..	1131.4	sq. ft.
Heating surface of fire box	..	..	..	116.7	"
					<hr/>
Total	..	..	..	1,248.1	"

Area of fire-grate	..	..	..	17 sq. ft.
Pressure of steam	..	..	..	160 lb. per sq. in.

Weight in working order—

				tons.	cwt.	qrs.
On leading wheels	..	..	..	15	6	0
On driving wheels	..	..	..	16	8	0
On trailing wheels	..	..	..	10	13	0
Total engine				42	7	0
Weight of tender loaded	..	..	..	30	2	0

Grand total of engine and tender .. 72 9 0

Length of wheel base of engine and tender.. 38 ft. 1½ in.

The new class of tank engine, 62 type, for working local passenger trains, runs on eight wheels and has inside cylinders.

The four coupled wheels are 5 ft. 7 ins. diameter, placed in front, and a four-wheeled bogie is placed under the foot-plate. The cylinders are 18 by 26.

Weight in working order—

				Tons.	cwt.	qr.
On leading wheels	..	..	..	17	3	0
On driving wheels	..	..	..	18	0	0
On bogie wheels	..	..	..	17	0	0
Total				52	3	0
Total heating surface	..	..	..	1,248 sq. ft.		

The South-Western Company provides its engines with the Adams Vortex blast-pipe, which instead of being a simple tapered pipe, as generally employed, has a central tube through which the heated air from the lower rows of tubes is drawn. This blast-pipe is found to fully answer expectations, as will be seen from the following official statement.

From June, 1885, to June, 1889, the company mixed the coal in proportion of two-thirds Welsh coal to one-third hard coal; since that time, in consequence of the increase in price of Welsh coal, the proportion is reversed, and in consequence the consumption is increased, and thus destroys the means of comparison with former years. (See next page.)

[COPY.]
LONDON AND SOUTH-WESTERN RAILWAY COMPANY.—FUEL CONSUMPTION, &c.

Half-year ended	Number of Engines fitted with the Vortex Blast Pipe.	Number of Engines fitted with the Plain Pipe.	Total number of Engines.	Total Engine Miles.	Consumption of Fuel per Engine Mile.	Total Fuel Consumption.	Cost of Fuel per Ton.	Total cost of Fuel.	Saving from Half-year ended June 1886.	
									Tons.	£
June 30th, 1885 ..	nil	505	505	7,501,154	lb. 29·9	Tons. 100,246	£ 14·40	72,226	—	—
December 31st, 1885 ..	9	496	505	7,915,420	29·2	103,310	14·58	75,327	2,473	1,803
June 30th, 1886 ..	49	492	541	7,465,775	28·8	95,905	14·27	68,453	3,666	2,616
December 31st, 1886 ..	147	389	536	8,113,054	27·9	101,368	13·58	68,871	7,243	4,918
June 30th, 1887 ..	230	299	529	7,849,983	27·3	95,821	13·39	64,164	9,111	6,100
December 31st, 1887 ..	253	281	534	8,628,045	26·3	100,158	13·40	67,166	13,705	9,182
June 30th, 1888 ..	278	256	534	8,156,403	26·5	96,356	13·42	64,660	12,380	8,307
December 31st, 1888 ..	301	247	548	8,508,771	26·8	102,129	13·51	69,005	11,775	7,954
June 30th, 1889 ..	324	226	550	8,166,380	27·3	99,685	12·98	64,715	9,478	6,151
									Total £47,031	

The latest South-Eastern express engines are designed by Mr. James Stirling and constructed at Ashford; they have a leading bogie and four coupled 7-foot wheels; the cylinders, placed inside, are 19 inches diameter and the stroke 26 inches.

The results of the working of six of these engines stationed at Dover, and each running about 1,000 miles per week upon mail and express trains between Dover and London, were as follows, and show very clearly the influence of weather and working generally during three different seasons of the years since the design was introduced.

MAY.

Average load 12 vehicles	= 120 tons	} = 190 tons.
Engine and tender	.. 70 "	
Average coal per train mile, 27·62 lbs.		

NOVEMBER.

Average load same as above, 190 tons.
Average coal per train mile, 30·37 lbs.

AUGUST.

Average load 15 vehicles	= 150 tons	} = 220 tons.
Engine and tender	.. 70 "	
Average coal per train mile, 28·72 lbs.		

The London, Chatham, and Dover Railway employs express engines designed and constructed by Mr. William Kirtley at its Longhedge Works. They have a leading bogie, four coupled wheels of 6 feet 6 inches diameter.

The cylinders are $17\frac{1}{2}$ inches diameter, by 26 inches stroke, the coupled wheels being 6 feet 6 inches diameter, and the tractive force therefore—

$$\frac{17\frac{1}{2}^2 \times 26}{78} = 102 \text{ lbs.}$$

for every lb. effective pressure on the piston. The boiler pressure is 150 lbs. per square inch.

The weight on the coupled wheels is $27\frac{3}{4}$ tons, or 62,160 lbs., and a tractive force equal to $\frac{1}{5}$ of the weight

available for adhesion would be given by a mean effective pressure of—

$$\frac{62160}{102 \times 6} = 121.8 \text{ lbs.}$$

per square inch, for which the cut-off required would be about 65 per cent. of the stroke.

The boiler, barrel, and fire-box shell are of best Yorkshire iron, the barrel made in two plates only, the circumferential seams being lap jointed and single riveted, and the longitudinal seams butt jointed and double riveted.

The top and sides of the shell are formed of one plate. The inside fire-box is of copper, the crown and sides in one plate, and the crown stayed by wrought-iron bars, secured by studs screwed through the crown plate into the bar with nuts on the underside. The fire-box stays are of copper. The back plate of the shell and the front tube plate are stayed by direct longitudinal stays, and the fire-box tube plate to the barrel by palm stays riveted to the latter.

	ft.	ins.
Height of centre of boiler from rail	7	2
Length of barrel	10	3
Diameter of barrel outside at largest part ..	4	3
Thickness of plates		$\frac{7}{8}$
Length of fire-box shell outside	5	9
Width of ditto at bottom	3	11
Depth of ditto from centre of boiler ..	5	2
Thickness of ditto plates	0	$0\frac{1}{2}$
Water space between fire-box and shell at bottom	0	3
Thickness of fire-box plates	0	$0\frac{1}{4}$
Ditto tube-plate	0	$0\frac{1}{2}$
Number of tubes, 199 (brass)		
Diameter of ditto outside	0	$1\frac{1}{4}$
Pitch of ditto	0	$2\frac{1}{2}$
Heating surface tubes	963 square feet.	
Ditto fire-box	107	„ „

Total .. 1,070
Grate area 16.5 square feet.

The fire-box is fitted with brick arch and deflector plate on the inside, and sliding doors on the outside, these being fitted with an auxiliary door or valve for regulating the admission of air to the fire-box, the main or sliding doors being always closed when running, so that no glare or heat from the fire is thrown on to the footplate or into the cab, to incommode the men, or affect their clear view of the signals by night. The grate bars are $1\frac{1}{4}$ inches wide at the top, and of wrought iron with $\frac{1}{2}$ -inch air spaces.

The London, Tilbury and Southend Railway works its passenger traffic with large ten-wheeled tank engines, having a leading bogie, four coupled wheels of 6 feet diameter, and a trailing pair of small wheels, the cylinders placed "outside" and 17×26 . The total weight of these engines is 56 tons.

The latest tank engines for the North London Railway have been designed and built by Mr. Park at Bow; they have outside cylinders $17\frac{1}{2} \times 24$, a leading bogie, four coupled wheels, and a steam pressure of 180 lbs. per square inch.

The North London Company's main line extends from Broad Street station to the junction with the London and North-Western system at Chalk Farm, and it has branches to Poplar and at Bow which bring up the total length of the railway to twelve miles.

The Company also is joint lessee with the North-Western and Midland of the North and South-Western Junction Railway, and by means of running powers over portions of the Great Northern, London and North-Western, and other lines, its trains traverse the western, northern, and eastern suburbs of London.

The traffic is heavy, the gradients severe (being 1 in 59 at Highgate), and the stations about half a mile apart.

The average mileage of the whole of the North London Company's engines equals 46,000 miles per annum, and the average fuel is 30 lbs. of coal per train mile.

The North London was one of the first companies to see and take advantage of high steam pressure. When other lines were using 120 lbs. and 140 lbs. per square inch, this line employed 160 lbs. with excellent results.

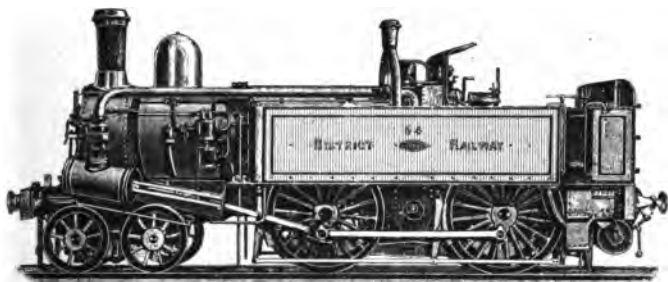


Fig. 83.—Metropolitan District Engine.

The Metropolitan and Metropolitan District Railways have both for many years worked their heavy and continuous passenger traffic with leading bogie, outside cylinder, four-coupled passenger tank engines, having cylinders 17×24 , and wheels 5 feet 9 inches. However, the latest Metropolitan engine has inside cylinders and a trailing bogie.

Fig. 83 shows that the engine has a leading bogie, four coupled wheels, and outside cylinders. This class of tank engine was originally designed for the underground railways by Sir John Fowler. On the opening

of the Metropolitan District Railway, the locomotive stock consisted of twenty-four of these engines, since increased to fifty-four, the whole of which have been built by Messrs. Beyer, Peacock & Co., of Manchester. These engines have proved remarkably satisfactory, as is clearly shown by the fact that when ordering new ones it has been found unnecessary to make any changes of importance in the dimensions. The chief dimensions of No. 54 are as follows:—

				ft.	ins.
Diameter of cylinders (17)	..	..	..	1	5
Length of stroke (24)	..	..	..	2	0
Length of ports	..	..	..	1	1 $\frac{1}{2}$
Width of steam ports	..	..	..	0	1 $\frac{1}{2}$
Width of exhaust ports	..	..	..	0	2 $\frac{1}{2}$
Between centres of cylinders	..	..	..	6	0
Between centres of valve spindles	..	..	..	2	10 $\frac{1}{2}$
Diameter of piston rods	..	..	..	0	2 $\frac{1}{2}$
Lap of valves	..	..	..	0	0 $\frac{1}{2}$
Lead of valves	..	..	..	0	0 $\frac{1}{2}$
Throw of eccentrics	..	..	..	0	2 $\frac{1}{2}$
Diameter of bogie wheels (new)	..	..	..	3	0
Diameter of coupled wheels (new)	..	..	..	5	9 $\frac{1}{2}$
Total wheel base	..	..	..	20	9
Diameter of boiler (inside)	..	..	..	4	0
Length of boiler, between tube plates	..	..	..	10	6 $\frac{3}{8}$
Diameter of tubes	..	..	..	0	2
Number of tubes	..	..	..	164	
Working pressure of steam	..	..	..	130	lbs.
Diameter of blast-pipe	..	..	..	0	5 $\frac{1}{2}$

When working in tunnels the exhaust steam is discharged into the water tanks.

Weight in working order:—

				tons.	cwts.
On bogie wheels	..	..	..	10	17
On driving wheels	..	..	..	18	1
On trailing wheels	..	..	..	17	12
Total				46	10

On journeys round the "inner circle" the author finds the number of booked stops is twenty-seven, in

addition to which there are always several due to signals; the distance is thirteen miles, and the time occupied in running sixty-eight minutes. The load hauled on all the circle trains and also over the gradients above mentioned is a train of nine coaches weighing from 75 to 87 tons empty. There are also a few local trains of five coaches running between High Street, Kensington, Putney Bridge, Earl's Court, Chiswick Park, and on the Hounslow branch.

The entire stock of the Metropolitan District Company, consisting of fifty-four engines and 350 carriages, is fitted with the Westinghouse automatic brake, and it is a fact worthy of note that although constantly stopping trains this brake works without a single fault or delay being caused.

The Company's locomotives undergo a general repair once in about two and a half years, and are practically in constant work from one general repair to the next, one shed day in seven being the only time they are cold.

The author finds the coal sheet to be remarkably good, considering the constant starting of trains, the heavy work, and severe gradients, the average consumption being less than 30 lbs. per mile. It must also be remembered that the entire railway consists of curves, there being hardly any straight road, and many of the curves are so sharp as to require check rails.

The Great Eastern Company has several useful classes of express engine, in addition to those illustrated, Fig. 79, namely the old "single" engines designed by Mr. Sinclair, and the large bogie express engines of the 602 class, having cylinders 18×26 and driving-wheels 7 feet 6 inches diameter.

There is also the Coupled Compound Engine, No. 230, built by Mr. Worsdell.

The Lancashire and Yorkshire Railway, having heavy gradients and frequent stoppages, requires engines of considerable power. That company, therefore, employs engines having a leading bogie, four coupled wheels of 6 feet diameter, and cylinders $17\frac{1}{2} \times 26$, also the latest class having cylinders 18×26 and 7 feet 3 inches coupled wheels.

The North British Railway is also one requiring power: we therefore find bogie express engines with four coupled wheels of 6 feet 6 inches diameter and cylinders 18 by 26.

On the Caledonian Railway several powerful engines are employed. Mr. Drummond has constructed bogie express engines with cylinders 18 by 26 and 6 feet 6 inches coupled wheels, and engine No. 124 has 19 inch cylinders. Boilers with various pressures from 150 to 200 lbs. per square inch have also been tried upon this railway.

The tank engines for working the passenger traffic between Liverpool and Birkenhead through the Mersey tunnel are of exceptional power, the gradient to be ascended being no less than 1 in 27; the engines of the No. 1 class have six coupled wheels of 4 feet 7 inches diameter and a trailing bogie, the cylinders are 21 inches diameter and 26 inches stroke, the total weight of this engine being 68 tons. This great power and weight enable these engines to stop at any point within the tunnel, and start away with their trains upon the heavy gradient of 1 in 27.

From the opening of the St. Pancras Station for the Midland Company's main line trains, in 1868, until the

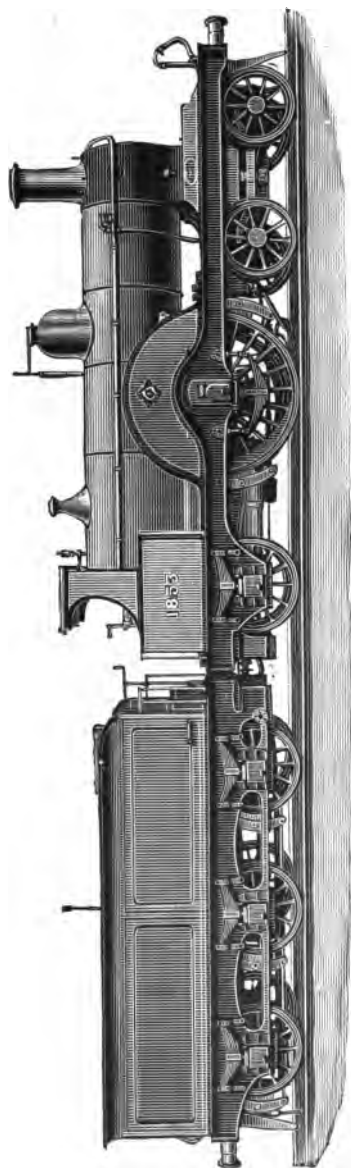


Fig. 84.—The Latest Design of Midland Express Engine.



year 1887, the whole of the express trains to London were worked by engines having four wheels coupled, but in that year Mr. S. W. Johnson designed and constructed some engines having a "single" pair of driving wheels, 7 feet 4 inches diameter, cylinders 18 by 26 and steam pressure 160 pounds. Two years later, 1889, he designed a still larger class (see Fig. 84) having cylinders $18\frac{1}{2} \times 26$, and 7 feet 6 inches wheels.

Total heating surface	1,240 sq. ft.
Pressure of steam.. .. .	160 lbs.
Weight on driving wheels	$17\frac{1}{2}$ tons.
Weight of engine in average working order	43 tons.
Weight of tender	30 "
<hr/>	
Total	73 tons.
Tender, water capacity	3,250 gallons.

Fifty of these engines are now working between London and Leicester, London and Nottingham, and Liverpool to Marple, also between Bristol and Derby. The fact that engines of this type are working the main line express trains over the London line, having severe gradients (see Fig. 85), for instance, Irchester and Sharnbrook of 1 in 120, at high speed, and upon a coal consumption of 20 to 23 pounds per mile, is the most convincing proof of their great efficiency.

Considering the loads, speed, and gradients, the work which has to be performed between London and Leicester is as hard or harder than any locomotive work in the country. Leaving London, the line rises for about 12 miles to Elstree, thence followed by a fall of 1 in 200 for about two miles to Radlett, when the rise continues to Leagrave. The engine, therefore, has

practically a constant pull up 1 in 176, and 1 in 200, until it has run 33 miles, when the line falls to Bedford upon gradients of 1 in 200, and speed has to be reduced to 15 miles an hour passing that station, which is a bad beginning for the rise to Sharnbrook summit, which is the top of both the Sharnbrook and Irchester Banks, of 1 in 120. Having run down to Wellingborough, the up-hill work continues past Kettering to the Desborough North Box, which is at the summit of two banks, of 1 in 132, and from Market Harborough up-hill work follows to the summit at Kibworth North Box, thence (with the exception of a dip at Glen) the line falls to Leicester. It will thus be seen that there are long lengths of 176, 120, 132, and at Kibworth a short length of 1 in 100. The Scotch trains now perform the distance, $99\frac{1}{2}$ miles, with a load of $10\frac{1}{2}$ coaches, in 115 minutes.

The Nottingham expresses are allowed 80 minutes between Kentish Town and Kettering, $70\frac{1}{2}$ miles, or an average from start to stop of nearly 53 miles an hour; and when riding in the trains the writer has very frequently timed the run in less than 78 minutes, and upon no occasion has he been a passenger when one of these engines has ever lost any time.

The "Greater Britain," designed and constructed by Mr. Webb at Crewe, ran its first trip on the 4th November, 1891.

The general principle of the design of the "Greater Britain" is identical with the other compounds. The high-pressure cylinders are 15 inches diameter, and the low-pressure cylinder is 30 inches diameter, the stroke in each case being 24 inches. As far as tractive force is concerned, the engine is said to be equivalent

to a non-compound locomotive having a pair of 21-inch cylinders with a 2-feet stroke, the driving wheels being 7 feet 1 inch diameter.

The special feature in the "Greater Britain" is the design of the boiler, which has been made with a very long barrel to allow of both driving-axes being placed under it. The tubes are divided into two lengths by a combustion chamber, those extending from the fire-box to the combustion chamber being 5 feet 10 inches long between tube-plates, while those forming the front group are 10 feet 1 inch long.

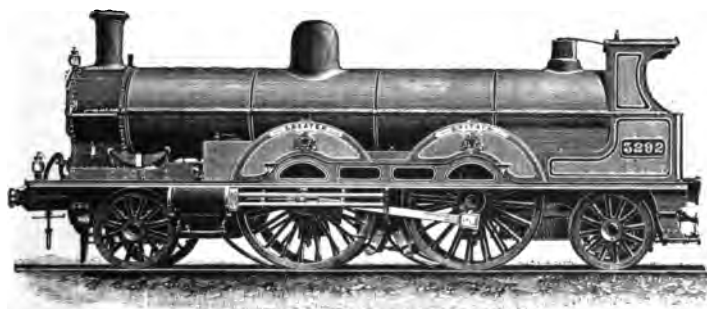


Fig. 86.—Mr. Webb's Latest Design of Compound Engine.

Heating surface of firebox	120.6 sq. ft.
„ „ combustion chamber	39.1 „ „
„ „ tubes (front)	853.0 „ „
„ „ tubes (back)	493.0 „ „
Total	1,505.7 sq. ft.

Pressure of steam 175 lbs. per sq. inch.

Weight of engine in working order .. 52 tons 2 cwt.

Weight of tender 25 „ „

Total 77 tons 2 cwt.

Sufficient time has not yet elapsed for this engine to prove her cost of maintenance ; but, so far, facts appear to show that the difficulties which attend "compound" express engines have not yet been successfully overcome.

The following particulars of the London and North-Western route show the gradients over which the engines work.

Leaving Euston the line passes under the Hampstead Road and immediately commences to rise upon gradients of 1 in 66, 1 in 110, 1 in 132, and 1 in 75 to Camden. Having once overcome the Euston incline, the engine has before it a splendid run to Crewe. There are summits at Tring, Blisworth, Kilsby, Atherstone, and Whitmore ; but with the exception of the rise near Whitmore, the engines upon either the up or down journey have practically to work throughout upon gradients of not more than 1 in 330, or 16 feet per mile.

North of Crewe the gradients become more severe until, upon passing the 243rd mile-post, the engine commences to ascend long and severe gradients, and from Tebay to Shap-summit, a "bank engine" is employed to assist the trains up the incline of 1 in 75, after which the line falls to Carlisle.

The most severe gradient is 1 in 75 going north, and 1 in 95 between Carlisle and Shap travelling south. It is under consideration to make a tunnel and new line under Shap-summit. If this plan be carried out, both these severe gradients will be avoided.

During the year 1891, and early part of 1892, thirty new express engines were built at the Swindon works of the Great Western Railway from the designs of Mr.

William Dean, to take the place of the broad gauge engines on the 23rd May, 1892.

The new engines are numbered from 3,001 to 3,030, and run upon six wheels, have double frames, a single pair of driving wheels, 7 feet 8 inches diameter, and a pair of inside cylinders no less than 20 inches diameter (Fig. 87).

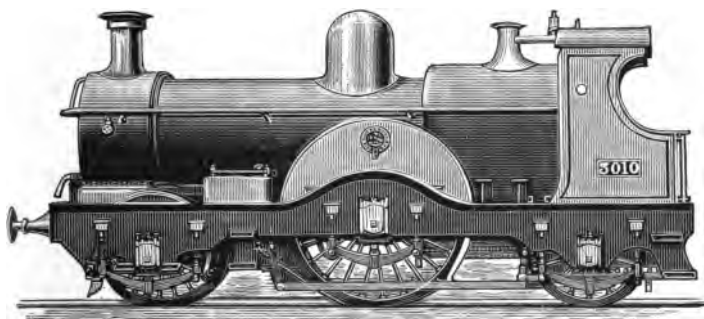


Fig. 87.—Mr. Dean's Latest Design.

The chief dimensions of these splendid locomotives being as follows:—

Diameter of cylinders	..	..	..	20 ins.
Length of stroke	..	..	..	24 "
Diameter of driving wheels	..	..	..	7 ft. 8 ins.

The tractive force exerted for each pound of effective steam pressure per square inch in the cylinders being, therefore, thus—

$$\frac{20 \times 20 \times 24}{92} = 104.3478$$

The steam pressure carried being 160 lbs. per square inch, and the weight available for adhesion 19 tons,

it follows that the engines are capable of performing fast and very heavy work. The boilers of these new engines are provided with a dome, an advantage which the old engines (Figs. 44 and 54) did not have.

Distance apart between centres of cylinders ..	2 ft. 3 ins.
Length of boiler between the tube plates ..	11 ft. 9½ ins.
Mean diameter of telescopic boiler inside ..	4 ft. 1½ ins.
Number of tubes	245
Diameter of tubes (outside)	1½ ins.
Pressure of steam	160 lbs.
Heating surface of tubes	1,321·04 sq. ft.
Heating surface of fire-box	123·88 „ „
	<hr/>
	1,444·92 „ „
Area of fire-grate	20·8 sq. ft.
Length of wheel-base	18 ft. 6 ins.

Weight of engine in working order—

On leading wheels	13 tons 4 cwts.
On driving wheels	19 „ 0 „
On trailing wheels	11 „ 18 „
	<hr/>
Total	44 „ 2 „
Weight of tender full	32 „ 0 „
	<hr/>
Grand total, engine and tender	76 „ 2 „

The tender runs upon six wheels, and carries 2½ tons of coal, and 3,000 gallons, or 13 tons 7 cwts. and 96 lbs., of water.

It is an admitted fact that the “battle of the gauges” has ended completely in favour of the narrow gauge; however, now the Great Western Company has made the change, it has given proof that it intends to have some of the finest narrow-gauge express engines that can be constructed. When we see the fine new engines which Mr. Dean has built for the 4 feet 8½ inch gauge, we cannot help feeling great regret

that Mr. Brunel did not devote his great skill and energy to the perfecting of the narrow-gauge engine, instead of introducing a wide gauge which has now had to be removed.

The gradients upon the Great Western Railway between London and Bristol are, with two exceptions, extremely favourable.

Leaving Paddington the line rises very gradually for about 11 miles to near Hayes, thence there is a decline of one in 1,716; from West Drayton to Swindon there is a very gradual rise, but the gradients are only about 1 in 1,320, 1 in 660 being the most severe.

Near to Dauntsey, there is about $1\frac{1}{2}$ miles of 1 in 100, and through Box Tunnel the gradient is also 1 in 100, these inclines in both cases being against the up trains. From Box to Bristol the line falls upon easy gradients.

The rise of 1 in 100 through Box Tunnel has often been described as the *bête noire* of engine drivers; however, it is not likely that they will be much troubled by engines "slipping" when the driving wheels carry 19 tons and are provided with a good supply of sand.

Already these new engines have proved beyond question that the broad gauge was a mistake, and that whatever has or can be done upon the wide gauge can be equally well done upon the 4 feet $8\frac{1}{2}$ inch gauge.

Messrs. Sharp, Stewart & Co., of the Atlas Works, Glasgow, recently placed twenty new bogie express engines upon the Midland Railway, built from Mr. Johnson's designs, Nos. 2,183 to 2,202; they have cylinders $18\frac{1}{2}$ by 26, 7-foot driving wheels, 4 coupled, and a steam pressure of 160 lbs. per square inch;

they are also provided with the apparatus for warming the carriages by hot water, now adopted by the Midland; and for working local passenger traffic upon the same line a number of "bogie" tank engines have been built, having four coupled wheels of 5 feet 3 inches, cylinders 18 by 24, and a pressure of 140 lbs.

The Great Southern and Western Railway Company of Ireland owns the main line extending from the Kingsbridge station, Dublin, to Queenstown, the distance being $177\frac{1}{4}$ miles; and it is by this route that passengers and mails are conveyed to and from Queenstown in connection with the American liners.

The gauge of the Irish railways is 5 ft. 3 ins.

For many years past the Great Southern and Western Company has built all its engines and rolling stock at its Inchicore Works, near Dublin.

The latest express engine has inside cylinders, a leading bogie, and four coupled wheels.

				ft.	ins.
Diameter of cylinders	..	..	..	0	18
Length of stroke	..	..	..	0	24
Diameter of coupled wheels	..	..	..	6	6
Diameter of boiler	..	..	..	4	3
Length of boiler barrel	..	..	..	9	9
Diameter of tubes (outside)	..	..	..	0	$1\frac{1}{2}$
Length of tubes between tube plates	..	..	..	10	$0\frac{1}{8}$
Length of fire-box	..	..	..	4	10
Width of fire-box	..	..	..	3	11
Height of fire-box above grate	..	..	..	5	9
Pressure of steam	..	..	150 lbs. per sq. in.		
Number of tubes	..	..	..	204	
Heating surface of fire-box	..	..	..	112	sq. ft.
Heating surface of tubes	..	..	..	938	„
Total				1,050	„
Area of fire-grate	..	..	..	$18\frac{1}{2}$	„

Weight of engine in working order—

					tons.	cwt.
On bogie wheels	..	..	..	..	13	11
On driving wheels	..	..	..	..	12	17
On trailing wheels	..	..	..	..	12	16
Total					39	4
Weight of tender loaded	..	..	..	..	28	6
Grand total					67	10

The leading bogie is of the American swing-link pattern. The boiler and frame plates are of steel, and the motion plate is cast steel; the two cylinders are cast together in one piece, and have the back covers and air passages for the vacuum brake cast in; these passages being in communication with the ejector, which is placed in the smoke-box, in front of the blast-pipe.

The bearings of the small ends of the connecting-rods are iron, case-hardened, working on a case-hardened pin, this being the universal system of "little end" in use on the line. The four eccentric sheaves are cast in two pieces and put on the axle with four bolts; no keys are used, but a small dowel secures the correct position of the sheaves.

The tender runs on six wheels, and carries 2,700 gallons of water and four tons of coal.

The actual working upon the American mail and express trains between Dublin and Queenstown is as follows:—

On weekdays the mail starts from Dublin at 7.40 A.M., and arrives at Queenstown at 12.15 P.M. The time on the journey of $177\frac{1}{4}$ miles is, therefore, 4 hours 35 minutes, of which, however, 18 minutes are allowed at stations; the average speed, including stoppages, is therefore 42.16 miles an hour, which is found to mean

an average running speed of 45 to 50 miles an hour. On Sunday the mail is run at a somewhat higher speed. The average load is equal to $9\frac{1}{2}$ six-wheeled coaches.

	tons.	cwt.
Weight of engine and tender	67	10
Weight of $9\frac{1}{2}$ coaches .. .	120	0
Total weight of train	187	10

The consumption of South Wales steam coal is from 24 lb. to 26 lb. per mile with this load. The weight of train frequently exceeds this average, and the engines are capable of working fifteen to eighteen vehicles without difficulty.

The gradients are not considered severe, with the exception of the incline at Cork of 1 in 60, and at Dublin of 1 in 85. There are, however, several short lengths of 1 in 172, 180, 128, 140, and 151.

The latest express engines for the Great North of Scotland Railway have been constructed by Messrs. R. Stephenson & Co., and are required to run 4,000 miles consecutively without showing any defects in material or workmanship, and they have just completed this mileage to the entire satisfaction of the Great North of Scotland Railway Company.

The engines are eight-wheeled, there being two pairs of coupled wheels 6 ft. $6\frac{1}{2}$ in. diameter and a four-wheeled bogie at the leading end, the bogie wheels being 3 ft. $9\frac{1}{2}$ in. diameter. The engines have inside cylinders 18 in. in diameter and 26 in. stroke, the cylinders being cast together in one piece, the slide valves being placed on the top of the cylinders, and driven by a link motion and rocking levers. This is a very neat arrangement, designed by Mr. Manson, and has given every satisfaction. The engines are fitted

with balanced slide valves, also designed by Mr. Manson. The pressure on the back of the valve is relieved by a ring, which is held up to the casing door by a light tripod spring.

This arrangement greatly reduces the wear and tear of the valves and gear, and since adopted on the Great North of Scotland Railway, engines have run 100,000 train miles, the wear of the slide valves being only $\frac{3}{16}$ in.

The bogie is provided with the ordinary swinging arrangement, which enables the engine to pass round curves with perfect steadiness. The main frames, which are of steel, are set in at the front end to give sufficient clearance for the bogie wheels. The wheels are of wrought iron, and the coupled wheels have the balance weights forged solid.

The boiler barrel and fire-box casing are of best Yorkshire iron, the internal fire-box and tubes being of copper. There are 1,087 square feet of heating surface in the tubes, and 106 square feet in the fire-box, giving a total heating surface of 1,193 square feet. The grate surface is 18 square feet; the fire-box is fitted with sixteen copper air tubes, 3 in. external diameter, No. 7 w.g. thick, in two rows of eight in front and back, for conducting streams of air into the fire-box. This arrangement has been successfully used on the Great North of Scotland Railway for upwards of thirty years.

The tender is carried on eight wheels, the four hind wheels being connected to the main frame of the tender, and the four front wheels are connected to a bogie of the same design and construction as the engine bogie. The tank carries 3,000 gallons of water and about three tons of coal. The weight of the

tender when loaded with coal and water is 36 tons. These tenders are remarkable as being the only ones running on a bogie in this country.

The Great Eastern Railway Company has just placed upon its line some powerful six wheels coupled tank engines, designed by Mr. James Holden, to work the very heavy suburban passenger traffic to and from Liverpool Street. In order to ascertain the work done, the author has ridden with some of the trains, and finds that the booked time from Liverpool Street to Enfield is 40 minutes, the distance $10\frac{3}{4}$ miles with 16 stops. If each stop averages one minute, including stopping and starting, the actual running time is only 24 minutes, equal to a speed of 27 miles per hour. This, it must be remembered, includes no allowance for speed orders, stoppages or slowages due to adverse signals, &c. These trains average 15 carriages, with a gross load of 250 tons.

The cylinders are $16\frac{1}{2}$ inches diameter, the stroke 22 inches, and the coupled wheels 4 feet diameter, the tractive force being therefore—

$$\frac{16\frac{1}{2} \times 22}{48} = 124.7 \text{ lbs.}$$

Total heating surface	..	..	..	959 sq. ft.
Grate area	..	..	..	12.4 sq. ft.

Weight of engine in working order—

	..	..	..	tons.	cwt.	qr.
On the leading wheels	..	..	..	12	7	1
„ driving „	..	..	..	13	13	0
„ trailing „	..	..	..	13	19	3
Total	..			40	0	0
Capacity of tanks	..	..	..	1,000 gallons.		

These engines are working most satisfactorily, and

have considerably reduced the consumption of coal per mile.

For shunting purposes, and for working small branch lines, tank engines are usually employed.

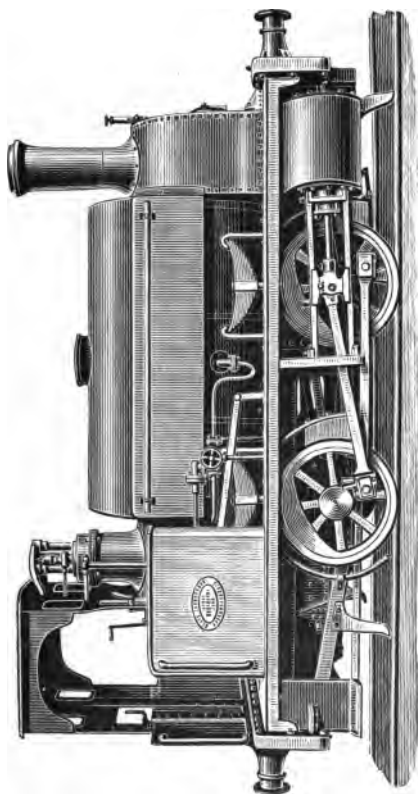


Fig. 88.—Four-wheeled Shunting Engine.

Fig. 88 illustrates a four-wheeled engine of the standard type manufactured by Messrs. Black, Hawthorn and Co., of Gateshead; and Fig. 89 illustrates a

more powerful engine which runs on six wheels, built by the same firm. The dimensions are varied in accordance with the work required, but most generally



Fig. 89.—Six-wheeled Shunting Engine.

the cylinders are about 15 inches diameter, and the stroke about 20 inches, the coupled wheels being 3 feet diameter. A small but at the same time a useful and very powerful engine is thus obtained.

CHAPTER V.

EIGHT-WHEELED COUPLED GOODS ENGINES.

For some time past it has been apparent that, with increased working expenses, some important step will have to be taken in order to increase the receipts per mile, especially of mineral trains.

Many of the railways are so crowded with passenger traffic that it is only by running coal trains at a high speed that they can be "got along at all." Long lengths of goods lines have been within the past few years opened, and the question of increasing the length and reducing the speed of coal trains to London must very soon be seriously considered. In order that coal traffic can be made to properly "pay," it should be conveyed in train loads of fifty waggons.

Messrs. Sharp, Stewart & Co., during the year 1889, placed two very powerful mineral engines upon the Barry Railway, the working of which has been carefully watched and proves highly satisfactory.

These engines run upon eight coupled wheels and have outside cylinders, and are of very considerable power.

Diameter of cylinders	..	..	..	20 ins.
Length of stroke	..	..	..	26 "
Eight coupled wheels	..	..	..	4 ft. 3. "

Total wheel-base 15 ft. 5 ins.
 The front axle has $\frac{1}{4}$ in. side play;
 The hind axle has $\frac{1}{4}$ in. side play; and
 The driving wheels are without flanges.

Total heating surface 1,410 sq. ft.
 Area of fire-grate 22.6 „

Weight of engine in working order without
 tender 49 tons.

From personal experience, the author can testify to the efficient manner in which these engines do their work, and it may be added that they are remarkably like the American well-known "Camel" class which for years has done such good work in America.

To Messrs. Sharp thus belongs the credit of introducing in this country the eight coupled engine with *outside* cylinders, and to Mr. F. W. Webb, of Crewe, in 1892, belongs the credit of introducing another eight coupled design but having *inside* cylinders.

This new engine runs upon eight coupled wheels and has two inside cylinders. The boiler is of great length, being similar to that of "Greater Britain," illustrated Fig. 86, the tubes being divided into two lengths by a combustion chamber, those extending from the fire-box to the combustion chamber being 4 feet 10 inches long between tube plates, and those forming the front group being 8 feet 1 inch long between tube plates. The cylinders, which are inside, are $19\frac{1}{2}$ inches diameter by 24 inches stroke, the valves being on the top and worked with Joy's gear. The springs on the first three pairs of wheels are connected together by equalising links, the trailing pair having an ordinary cross spring. The leading and trailing wheels have $\frac{1}{2}$ inch side play, which gives greater facility for running round curves.

Below are given a few leading particulars :—

Cylinders— $19\frac{1}{2}$ in. diameter by 24 in. stroke.

			ft.	in.
Diameter of wheels with 3-in. tires	..	..	4	$5\frac{1}{2}$
Distance between centres of wheels	..	..	5	9
Total wheel base	..	..	17	3

Boiler—

Length of barrel	..	..	15	6
„ fire-box casing	..	..	6	10
Diameter of barrel (mean)	..	..	4	3
Number of tubes—156				
Diameter of tubes	..	..	0	$2\frac{1}{8}$
Pressure of steam	..	160 lbs. per sq. in.		

Heating surface—

Fire-box	..	..	114·7
Combustion chamber	..	..	39·1
Tubes (front)	..	..	683
Tubes (back)	..	..	408·5

Total 1,245·3 sq. ft.

Grate area	..	..	20·5 sq. ft.
Ratio of fire-grate area to heating surface	..	..	1 to 60·6

Weight of engine in working order—

				Tons.	cwts.	qrs.
Leading wheels	..	..	..	11	13	0
Driving „	..	..	..	12	14	0
Intermediate „	..	..	..	11	13	0
Trailing „	..	..	..	10	16	3
Total	..	..	..	46	16	3

Weight of tender in working order, 25 tons.

The tractive co-efficient is 172. The leading and trailing wheels have a certain amount of side play, so as to give greater facility for running round curves, though the total wheel base is not more than other engines which have not the same side play. The coupling-rod from wheel to wheel is complete in itself, and all of them are so arranged as to be interchangeable. The driving-axle has two bearings as usual, nine inches long, and in addition a central

frame and central bearing to withstand the great stress placed upon it. The total bearing surface for the driving-axle is $23\frac{1}{2}$ square inches.

Engines with eight coupled wheels are, of course, very common in America, but Mr. Webb's new design is the first eight coupled and *inside* cylinders that has been built in this country, certainly during the past sixty years. The first of these powerful mineral engines is giving the greatest satisfaction on the London and North-western Railway, and there is every reason to believe that it will do so, as it has large cylinders, high steam pressure, and is non-compound.

CHAPTER VI.

AN AMERICAN ENGINE.

It is usual for Englishmen to believe, and to take it for granted, that English engines are the best, and to ignore the fact that some very useful locomotives are at work in other parts of the world. The Exhibition at Chicago this year will undoubtedly form the greatest collection of locomotives which has ever been made, and already the details which have arrived in this country show that the Americans especially will have some extremely fine engines, both in the Exhibition and in daily working. It is, therefore, important that some brief reference should be made to them in this volume.

The standard American passenger engine has a leading bogie, four coupled wheels, outside cylinders, and the usual bar-framing similar to that at first used by Stephenson and Bury. Some extremely fine specimens of locomotive construction, for instance, are to be found on the Baltimore and Ohio Railroad.

On the New York Central and Hudson River Railroad the engines are built partly by makers, but the larger number are turned out at the Company's shops at West Albany. The following dimensions show

that the engines have very considerable size and power.

The boiler has 1,821.5 sq. ft. heating surface. The usual working pressure is 180 lbs. The cylinders are 19 by 24 ins., and the driving-wheels are 7 ft. 0½ in. diameter.

The total weight of engine is 121,000 lbs., of which 81,000 lbs. are carried on the drivers and 40,000 lbs. on the bogie.

The tender weighs in service, 80,000 lbs. ; it carries 3,587 galls. of water and 7 tons of coal. It is provided with a scoop for taking up water from the track tanks without stopping. The total weight of engine and tender ready for service is thus 201,000 lbs.

These engines are employed in running the "Empire State Express" between New York and Albany, the schedule time of the train being 52 miles an hour. From some indicator diagrams taken while the engine was running at the rate of 76 miles an hour, it appears that at that speed there was 1,120 h.p. developed. The usual train is four cars.

The author has before him the particulars of a special run made on the 4th October, 1892, in which case another engine of similar design, with a tender weighing 201,000 lbs., and the weight of the train, 592,700 lbs., a total of 793,700 lbs. The train consisted of five ordinary passenger cars and five sleeping-cars. The run from Albany to Poughkeepsie was made in 1 hour 17 minutes, the average rate of speed being 54 miles an hour. The wind at the time was heavy, blowing from the west. The steam pressure during the run was kept at 160 to 170 lbs. The speed maintained was certainly remarkable, considering

the weight of the train. Two other fast long-distance runs were made by the Empire State Express in December, 1892. In one instance it ran 115.75 miles in 110 minutes, 51.67 miles being made in 46 minutes, or at the rate of 67.38 miles per hour. In the second case the train made 101 miles in 96 minutes, 28.43 miles being made in 25 minutes, or at the average rate of 68.23 miles per hour. In each case the train consisted of four cars and was hauled by an eight-wheel engine, with driving wheels 7 ft. $\frac{1}{2}$ in. diameter.

A two-cylinder compound engine has for some time been tried in America, and a few years ago one of the Webb compound engines was sent over from this country to America for use. However, the result of practical and perfectly fair tests is that the English engine was badly beaten.

The Baldwin Works has recently designed and built a large number of engines known as the "Vauclain compound."

In this system there are two high and two low pressure cylinders, but as each pair of cylinders works upon the same cross-head there are only two sets of connecting rods.

Cylinders, h.p.	..	..	..	..	13 X 24 ins.
Cylinders, l. p.	..	..	..	..	22 X 24 "
Boiler, form	..	..	..	..	wagon top.
" diameter	..	..	..	..	4 ft. 10 ins.
" height from rail to centre line	..	..	..	..	7 " 8 "
" pressure	..	..	..	..	180 lbs. per sq. in.
Fire-box (for hard coal)	..	..	..	11 ft. 0 ins.	X 3 ft. 6 ins.
Grate area	..	..	..	..	38 $\frac{1}{2}$ sq. ft.
Tubes, number	..	..	..	..	250.
" diameter outside	..	..	..	..	2 ins.
" length	..	..	..	..	11 ft. 10 ins.
Heating surface, tubes	..	..	..	..	1,530 sq. ft.
" firebox	..	..	..	..	166 "
" total	..	..	..	..	1,696 "
Height from rail to top of smoke-stack	..	..	..	..	13 ft. 5 $\frac{1}{2}$ ins.

Capacity of tender tank	3,500 gals.
" " coal space	7 tons.
Driving wheels, diameter.. ..	6 ft. 6 ins.
Bogie wheels "	3 " 0 "
Tender wheels "	3 " 0 "
Wheel base, driving to trailing	7 " 6 "
" " truck	6 " 10 "
" " total	22 " 3½ "
Weight on driving wheels	88,400 lbs.
" " truck	35,400 "
" " total	123,800 "
" " of tender	82,000 "

Practical trials appear to prove that if compound engines are to be employed, the four-cylinder pattern is far better than those used in England: but it is still a question whether a "simple" engine with two cylinders of an equal area, or a four-cylinder high pressure engine would not give as good or even better results.

MR. WINBY'S DESIGN.

This fact appears to have induced Mr. F. C. Winby to design an English engine to send to the Chicago Exhibition, and at the time of writing it is nearly completed at the well-known works of Messrs. R. & W. Hawthorn, of Newcastle. This vast locomotive will be, in fact, a combination of a McConnell "Bloomer" and a Crampton "Liverpool."

The engine runs upon a four-wheeled leading bogie, and two pairs of independent driving-wheels of 7 ft. 6 ins. diameter. Two inside cylinders are placed under the smoke-box, 16½ by 24; they actuate the first pair of driving-wheels. Two outside cylinders are placed behind the bogie wheels; they are 17 by 22, and work the second pair of driving wheels.

The total tractive force exerted by the four cylin-

ders upon the four wheels is therefore 143 lbs. for each pound of effective pressure.

The boiler is to work at a pressure of 175 lbs., but it is constructed to carry 200 lbs. if necessary.

The boiler is of oval section in order that it may be placed between the tops of the driving wheels.

Number of tubes	189.
Diameter of tubes	2 $\frac{3}{4}$ ins.
Length of tubes	16 ft.
Heating surface of tubes	1,880 sq. ft.
Heating surface of fire-box	138 "
Total heating surface	2,018 "
Area of fire-grate	28 "

Weight in working order will probably be—

On bogie wheels	18 tons.
On 1st driving wheels	19 "
On 2nd driving wheels	18 "
Total	55 "

The tender when loaded will be fully 45 tons, so that the engine and tender complete may be expected to weigh about 100 tons.

The only means of knowing the capabilities of a new design of locomotive is by the actual results of its working; at present, therefore, it is impossible to express an opinion. Suffice it to say that Mr. Winby has designed, and Messrs. Hawthorn are constructing, the largest locomotive ever seen in England, and the fact that the engine uses high pressure steam in all the cylinders is a most important feature in its favour, and its construction is being watched both in this country and in America with the very greatest interest.

CHAPTER VII.

LOCOMOTIVES OF THE UNITED KINGDOM—USEFUL RULES AS TO GRADIENTS—CENTRE OF GRAVITY OF LOCOMOTIVE—SUNDRY APPLIANCES.

LOCOMOTIVES OF THE UNITED KINGDOM.

THE following list, compiled by the author from official details, shows the locomotive engines possessed by each Company on the 31st December, 1891 :—

London and North-Western	2,648
Midland	2,020
*Great Western	1,660
North-Eastern	1,560
Lancashire and Yorkshire	1,127
Great Northern	907
Great Eastern	879
Caledonian	690
North British	677
Manchester, Sheffield, and Lincolnshire	655
London and South-Western	570
London, Brighton, and South Coast	410
South-Eastern	378
Glasgow and South-Western	301
London, Chatham, and Dover	201
Taff Vale	189
Great Southern and Western Ireland	178
Great Northern of Ireland	137
North Staffordshire	134

* The number of Great Western engines is given as stated by the Company, but the author is of opinion that there are a number of duplicates which have not been included.

Furness	123
Midland Great Western of Ireland	111
North London	104
Highland	85
Great North of Scotland	77
Metropolitan	71
Rhymney	66
Somerset and Dorset Committee	61
Belfast and Northern Counties	61
Cambrian	59
Hull, Barnsley, and West Riding	56
Metropolitan District	54
Barry	53
Dublin, Wicklow, and Wexford	51
Waterford and Limerick	42
Brecon and Merthyr	30
London, Tilbury, and Southend	30
Maryport and Carlisle	27
Newport and South Wales	24
Belfast and County Down	20
Cork, Brandon, and South Coast	16
Wrexham, Mold, and Connah's Quay	16
Mersey	15
City and South London (electric)	14
Severn and Wye	13
Waterford and Central Ireland	13
Seaham and Sunderland	11
Rhondda and Swansea Bay	10
West Lancashire	9
Festiniog	9
Isle of Wight	8
Isle of Wight Central	8
Midland and South-Western Junction	8
Cavan, Leitrim, and Roscommon	8
East and West Junction Committee	7
Pembroke and Tenby	7
Wirral	7
Manchester and Milford	6
South Wales Mineral	6
Portpatrick and Wigtownshire Committee	6
Londonderry and Lough	6
Waterford, Dungarvan, and Lismore	6
Clogher Valley	6
Cleator and Workington Junction	5
Neath and Brecon	5
Ayrshire and Wigtownshire	5
Dundalk, Newry, and Greenore	5
Sligo, Leitrim, and Northern Counties	5
Burry Port	4
Colne Valley and Halstead	4
Llanelly and Mynydd Mawr	4

Cork and Macroom	4
Waterford and Tramore	4
Cork and Muskerry	4
Tralee and Dingle	4
West Carberry	4
West Clare	4
Corris	3
Liakeard and Caradon	3
North Wales (narrow gauge)	3
Redruth and Chasewater	3
Ballycastle	3
Cork and Blackrock	3
Finn Valley	3
Listowel and Ballybunion	3
Bishop's Castle	2
East Cornwall	2
Garstang and Knot End	2
Glyn Valley	2
Mawddwy	2
Merrybent and Darlington	2
Ravenglass	2
Snailbeach District	2
Southwold	2
Tallylyn	2
Van	2
West Somerset	2
Bessbrook and Newry (electric)	2
Timoleague	2
Easingwold	1
Gorsedda Junction, Portmadoc	1
Milford Haven	1
St. Austell	1
Saundersfoot Railway	1
Storksbridge	1

TOTALS.

England and Wales	14,314
Scotland	1,841
Ireland	705

Total engines in the United Kingdom on 31st
December, 1891 16,860

USEFUL RULES RELATING TO GRADIENTS.

The *vis viva* of a train moving at any given speed is equivalent to the raising of the train to the height, by falling through which it would attain that velocity, and this is true whether the train is raised vertically (if it were possible), or by running it up an incline assuming friction as nil.

Therefore when a train runs up an incline, the engine has not only to overcome the resistance on the level, but also to raise the train to a certain height.

An incline of 1 in 200, for instance, is a rise of $\frac{5,280}{200} = 26.4$ feet per mile. To find the work done (in foot tons) in lifting a train of 200 tons through the vertical height of 26.4 feet, it is necessary to multiply the height by the weight, thus, $200 \times 26.4 = 4,280$ foot tons.

The rates of inclinations of gradients are also conveniently expressed as percentages, which represent the force of gravity acting on different inclines—1 in 200 being expressed as a gradient of 0.5 per cent. ; 1 in 100 as 1 per cent.; and 1 in 50 as 2 per cent.

In this country, it is still the practice to express gradients in their proportion or ratio to 100, but in America, as in many other parts of the world, gradients are always given in proportion to their rise per mile. To find the rise in feet per mile for any given incline, it is only necessary to divide the feet in a mile (5,280) by the gradient to one; thus in a case of 1 in 264 we have

$$\frac{5,280}{264} = 20 \text{ feet per mile.}$$

When, therefore, the English engineer speaks of 1 in 264, the American engineer refers to it as "a 20-foot grade."

The following table gives the same inclinations expressed by the two methods :—

Gradient to 100.	Equal rise in feet per mile.	Gradient to 100.	Equal rise in feet per mile.
1 in 2,000	2·64	1 in 165	32·0
„ 1,000	5·28	„ 132	40·0
„ 500	10·56	„ 120	44·0
„ 400	13·2	„ 100	52·80
„ 300	17·6	„ 88	60·0
„ 264	20·0	„ 70	75·42
„ 220	24·0	„ 50	105·6
„ 200	26·4	„ 37	142·7

CENTRE OF GRAVITY OF LOCOMOTIVE.

The horizontal centre of gravity of either a bogie or six-wheeled engine should be a few inches in front of the centre of the driving axle. To find this point, multiply the weight resting upon the leading wheels (or leading bogie, if one be used) by the distance in feet from the centre of the driving axle. Multiply the weight upon the trailing wheels by distance in feet from the driving axle. Find the difference, which divide by the total weight of the engine in tons; the quotient is the horizontal distance in feet of the centre of gravity from the driving axle in the direction of the axle carrying the greater weight. As an example, if an engine weighs 41 tons 13 cwt. 2 qrs.; on leading wheels, 14 tons 6 cwt.; on trailing wheels, 12 tons 16 cwt.

14·3 tons \times 10 ft. (for leading end of engine) .. 143· ft.-tons
 12·8 tons \times 8 ft. 6 in. (for trailing end of engine) .. 108·8 ft.-tons

The difference (34·2), divided by the total weight of the engine (41·68), = ·82 of a foot. Therefore the centre of gravity of the engine is ·82 ft., or 9 $\frac{1}{2}$ in. in front of the driving-axle.

When a locomotive is running, that portion of the tread of the tire which is in contact with the rail at

any instant of time is at rest, while the corresponding point on the flange on the same radius is moving in the opposite direction to that at which the train is running. The speed being 60 miles an hour, or 88 ft. per second, and the diameter of the wheel over the tread 6 ft., and over the flange 6 ft. 2 ins., the point in the flange will move backwards at the rate of 1·59 miles per hour.

THE STEAM SAND-BLAST.

Every engine-driver is well aware that for fast running, easy riding, and economy both in coal and repairs, nothing can equal an engine having a "single" pair of driving wheels. On the other hand practical experience has taught them that for heavy trains running upon steep gradients, it is absolutely necessary to employ engines having four coupled wheels, in order to obtain the required amount of adhesion, or, as the drivers say, "to tie their legs together."

The useful work which an engine is capable of performing is, of course, limited by the co-efficient or proportion of adhesion which exists, or can be created, between the driving wheels and the rails; in other words, as soon as the effect of the steam in the cylinders produces a tractive force greater than the adhesion, "slipping" is the result. In ordinary practice the co-efficient of adhesion is found to be equal to one-sixth of the weight resting upon the driving wheels expressed as an adhesion of 16·66 per cent., or as an adhesion of 373·3 lbs. per ton.

If the rails be perfectly clean and dry, the adhesion is increased; if perfectly wet, it is but little reduced. A slight shower of rain, misty weather, and greasy

rails will often reduce it to about 280 lbs. per ton ; and in frosty or snowy weather the writer proved by a series of practical experiments that the adhesion became as low as 160 lbs. per ton. It is, therefore, not a matter of surprise that such a serious loss of adhesion should cause a considerable amount of "slipping." To overcome the difficulty the ordinary method of sanding the rails is by means of sand-boxes and pipes which allow sand to run down on to the rails, and in practice it is found that a considerable quantity of sand is used, but a large proportion of it does not fall on the rails, and a further quantity is blown off the rails by the wind: consequently the ordinary sanding arrangement is very inefficient and unsatisfactory.

One of the most important improvements in locomotive engineering is the recent introduction by Messrs. Holt and Gresham of their steam sand-blast (Figs. 90 and 91).

The general arrangement is shown (Fig. 90), as fitted to some of the Midland Company's engines of the 1,480 and 1,500 classes. By means of a handle, "A," steam can be admitted to the sand-ejector, "C," thus drawing a small supply of sand from the sand-box, "B," and projecting it in a powerful and constant sand-blast to the point of contact between the wheel and the rail. Fig. 91 shows the apparatus in detail, and it will be observed that the sand falls into the sand trap, and is then carried down in a fine jet by the inrush of air caused by the steam ejector.

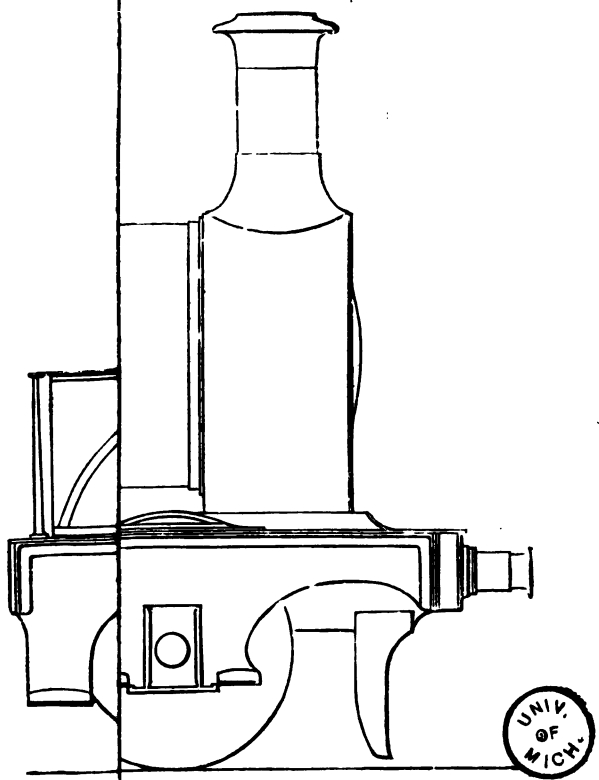
THE INJECTOR.

In the early days of railways the boilers of the locomotives were supplied with water by means of force-pumps worked by hand-levers; afterwards the pumps

per too
provi
sion to
not an
sion of
T.
sandir
pes w
in pa
nd is a
the
ls of
anger

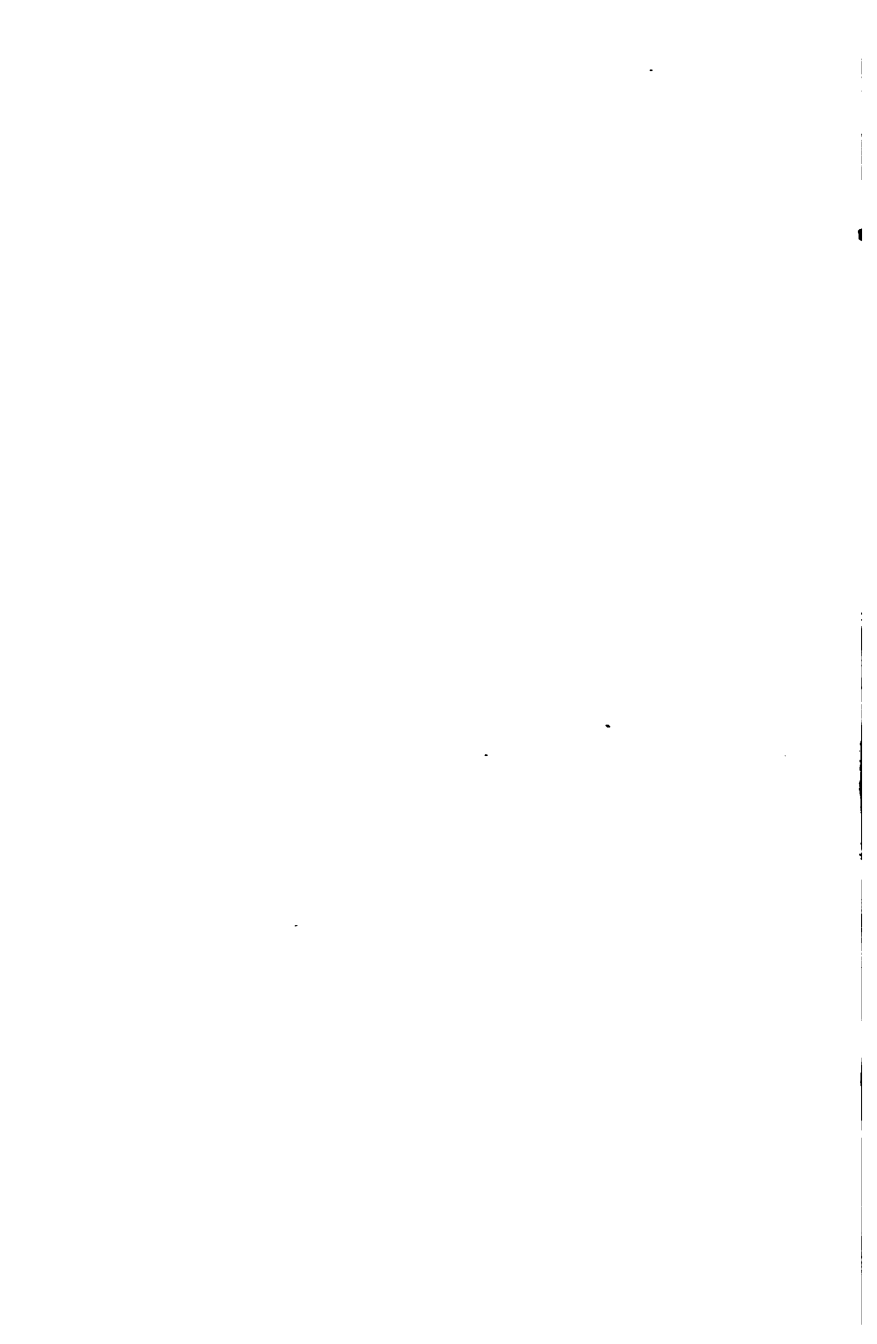
exam
Hib
nd to
as
ch
ba
r,
id
nes
wi
de
o
e

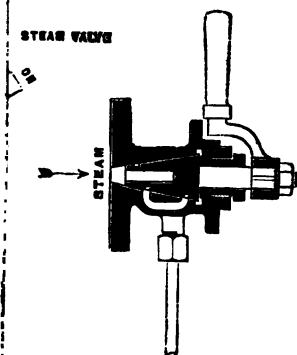
la
re
re



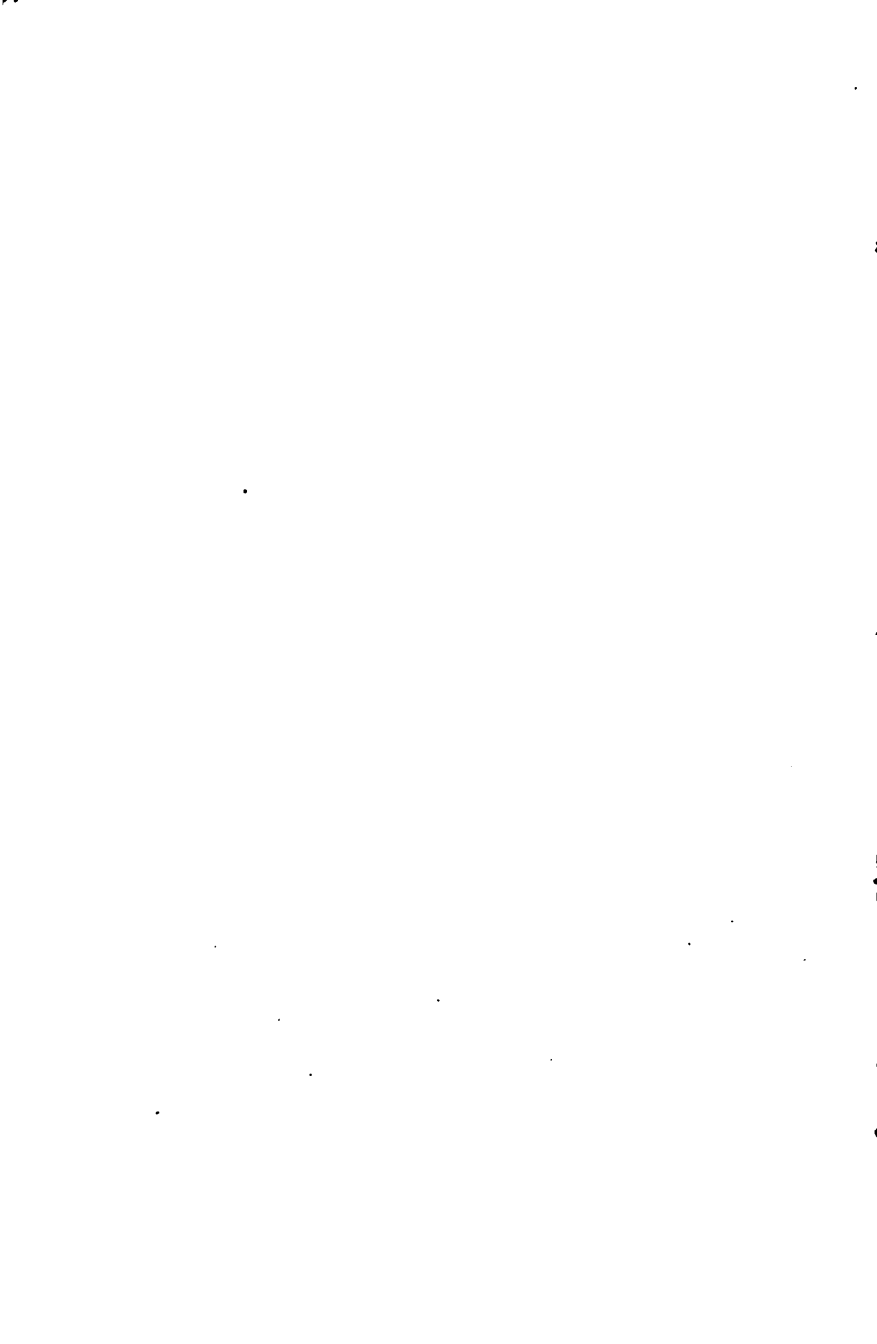
[To face p. 192.]







[To face p. 192.]



were worked by either eccentrics or rods attached to the cross-heads, and on the London and South-Western Railway an independent donkey pump was employed to feed the boiler, and at the present time some of the Brighton Company's engines are fed with water by means of a water pump, working in connection with the Westinghouse air brake pump.

Many of my "locomotive" readers will remember the time very well when engines had two pumps, and in order to supply water to the boiler it was necessary to run several times backwards and forwards for about a quarter of a mile to fill up the boiler.

They will also, no doubt, well remember seeing "single" wheeled engines standing in the sheds, with their tender brakes hard on, slipping upon oiled rails, in order to pump water into the boiler.

In July, 1858, Mr. H. J. Giffard, a French engineer, took out a patent for the "Injector"; he had discovered that the motion imparted by a jet of steam to a surrounding column of water was sufficient to force it into the boiler from which the steam was taken, and even into another boiler having a higher pressure.

When Mr. Giffard tried to introduce his new injector, locomotive engineers laughed at him; he was told to read about the first rules of motion, and that he must be mad to suppose that steam from one part of a boiler could force its way back into another part of the same boiler; he could not even obtain authority to try an injector on a locomotive till 1859, and then he was only granted permission as a favour and with a view to "let him prove his idea would not work," and thus put a stop to his constant letters and applications.

However, the injector worked successfully, and the

water entered the boiler, but even then people would not believe it.

Mr. Giffard explained that the action of his injector was similar to that of the blast-pipe in a locomotive: the rush of steam in that case formed a partial vacuum into which air was forced by the atmospheric pressure of about 15 lbs. per square inch.

To explain his theory Giffard took a pressure of 100 lbs. per square inch, and showed that a column of water 23-10 feet high presses upon its base with a force of 1 lb. per square inch, therefore 100 lbs. pressure is equal to a pipe of water 230 feet high.

Water from the bottom of a pipe 230 feet high would rush out at a speed of $121\frac{1}{2}$ feet per second, that is equal to no less a pace than 83 miles an hour.

Let it be clearly understood that a boiler having a pressure of 100 lbs. per square inch is just balanced by a jet of water rushing at 83 miles an hour: it then becomes certain that to overcome the steam in the boiler it is only necessary to increase the speed of the water to above 83 miles an hour, and the water will force itself into the boiler.

It is a well-known fact that the steam pressure in the valve-chest of a locomotive is actually greater than it is in the boiler, this being due to the momentum with which the steam rushes past the regulator and down the steam pipe.

In the same manner the velocity of the steam rushing through the injector is so great that it not only has force enough itself to rush back into the boiler, but also carries the water with it.

Giffard's patent has long since expired, and injectors are now made by various firms, principally by Messrs.

STEAM VALVE



face p. 195.

Gresham and Craven, who have upwards of 100,000 of their construction of injector in use. Fig. 93 illustrates the foot-plate of a locomotive, showing the position of Gresham's combination injectors.

Fig. 92 illustrates a section of the appliance, the

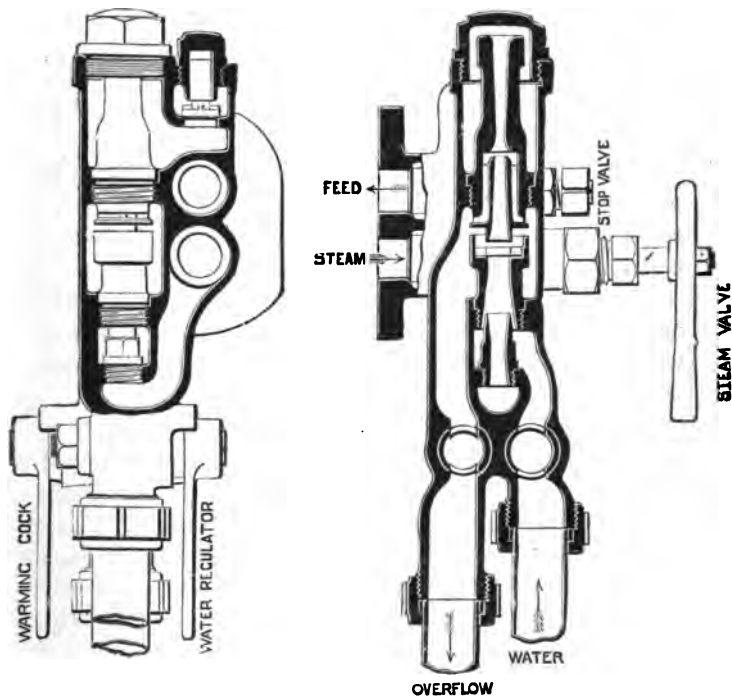


Fig. 92.—Details of Injector.

steam valve, back pressure valve, stop valve, and regulator being plainly shown.

The following are the instructions for working the Gresham combined injector:—

- (1) Open the water cock and turn on steam;

(2) If there is any overflow, close the water regulator until it ceases. The injector is then at work. The water cock should be kept closed when the injector is not at work.

The water pipe can be drained to prevent freezing by closing the tender valve and opening drain cock fixed on water pipe.

Should steam be blown into the tender through the injector, the water pipe must be drained to clear it of hot water.

The back pressure valve must be kept ground tight upon its seat. This can be done, or the whole of the cones can be removed if required, whilst the boiler is under steam by first closing the stop valve.

It is well known to engine-drivers that injectors will not work with very hot water, and in practice it is not advisable for the water in the tender to be heated to above 120 deg.

Having thus considered the theory of the injector, we now turn to its practical results; the annexed table shows the sizes 7 to 10 which are in general use on locomotives, and the number of gallons of water which each will supply per hour at pressures of from 100 to 180 lbs., and of course if the quantity per minute is required it is only necessary to divide the gallons by 60.

TABLE GIVING THE SIZE AND DELIVERY OF COMBINATION INJECTORS.

Size of Injector in Milli- metres.	BOILER PRESSURE IN LBS. PER SQUARE INCH.									
	100	110	120	130	140	150	160	170	175	180
DELIVERY IN GALLONS PER HOUR AT ABOVE PRESSURES.										
7 ..	970	1,020	1,060	1,110	1,150	1,190	1,225	1,255	1,265	1,275
8 ..	1,270	1,330	1,390	1,450	1,500	1,550	1,600	1,640	1,655	1,670
9 ..	1,610	1,680	1,760	1,830	1,900	1,970	2,030	2,080	2,100	2,120
10 ..	1,980	2,080	2,170	2,290	2,350	2,430	2,500	2,560	2,585	2,610

VALVE GEAR.

Reference has been made to several forms of valve gear, for instance, those described at pages 45, 62, and Howe's celebrated link motion (page 87). Whatever form of gear is employed, when the driver "reverses" the engine he moves one of the valves so as to open either the front or back port at pleasure. Now let us trace the action of the steam. Upon the regulator being opened, steam rushes from the dome or steam pipe down to the valve chest, where in consequence of the "lead" the valve is about one-eighth of an inch open when the crank is upon the dead centre (the two cranks are always made at right angles, so that one is in a position to pull the other past its dead point). The steam having entered past the valve, rushes into the cylinder, and the period of "admission" commences; the steam having forced the piston forward for a distance of let us say eight inches, the valve closes and no more steam is admitted; this is known as "cut off" or point of "suppression"; and for the next part of the stroke the piston is not forced by fresh steam from the boiler, but by the "expansion" of the steam which is imprisoned in the cylinder.

We will now suppose that "expansion" has done its work, and that the piston has been forced, say to 20 inches: the period of "release" then arrives, when the inside of the valve opens the port and permits the steam which has done its work to rush from the cylinder, through the inside of the valve to the exhaust port, and then up the blast-pipe and out of the chimney. The "lead" of the valve causes it to open before the piston arrives quite at the end of its stroke; this

serves two good purposes, first to form a cushion to reduce the force of the advancing piston, and secondly to enable steam to be entering the cylinder early, ready for the next stroke.

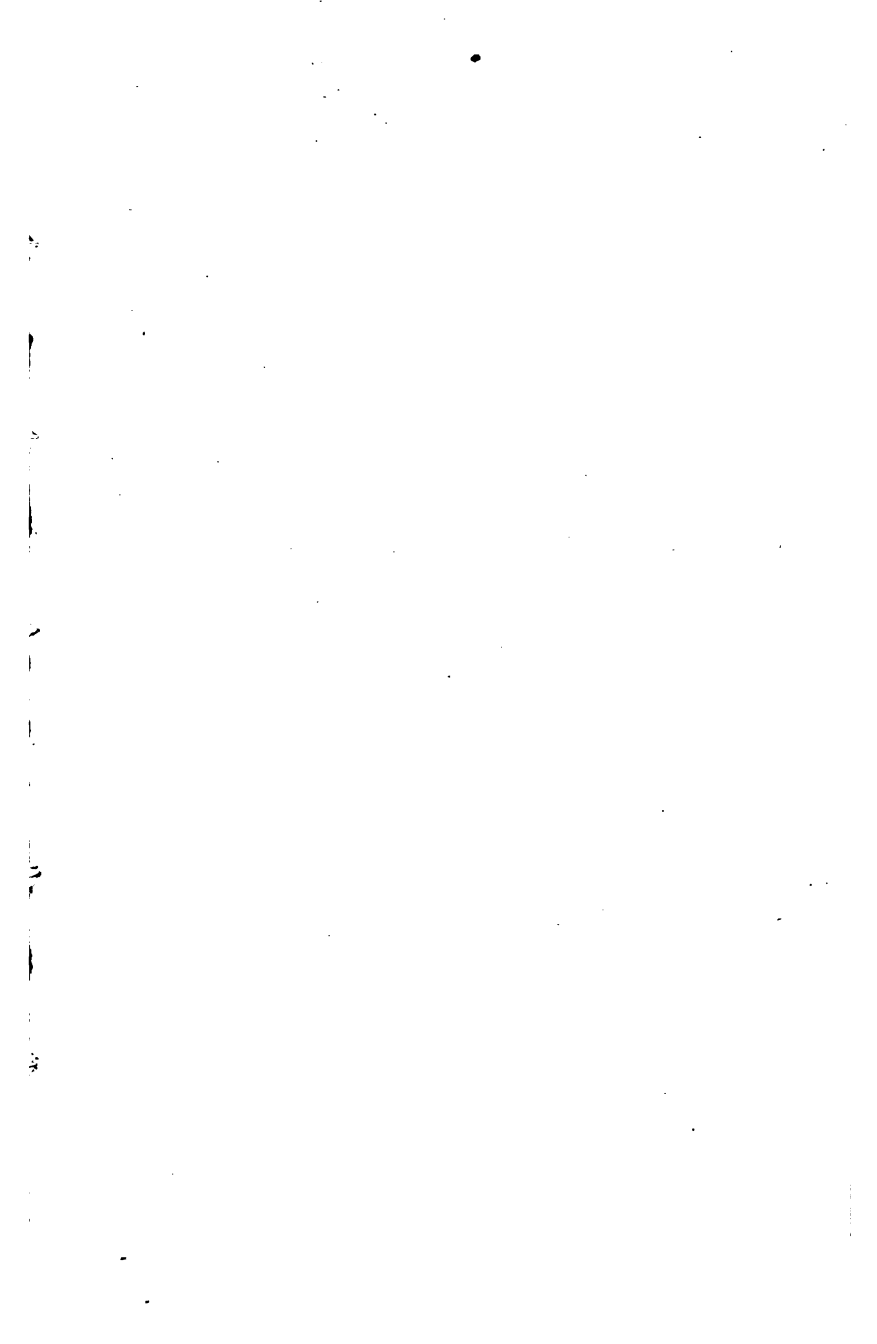
An express engine having wheels of 7 feet diameter, or 22 feet in circumference, passes over 88 feet, or four revolutions per second, when running at sixty miles an hour; thus in one second of time, there must be "admission," "cut off," "expansion," "exhaustion," and "compression," no less than four times from each end of the cylinder, or a total of sixteen "beats" or exhausts of steam up the chimney per second.

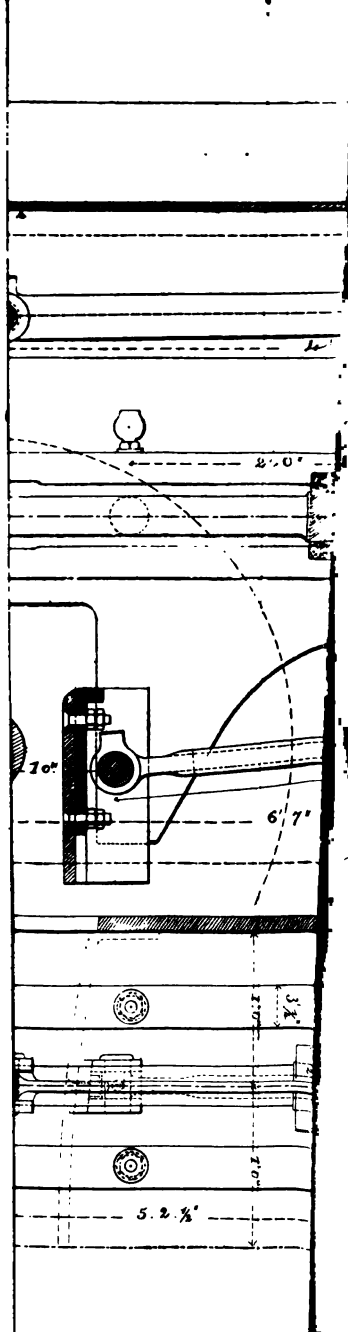
It is not necessary to tell engine-drivers that which they know perfectly well—namely, that to save steam and consequently coal, they, by carefully regulating the valve-gear and "cutting-off" the admission of steam to the cylinder *as early as possible*, can get the greatest amount of work and expansion out of the imprisoned steam in the cylinder.

JOY'S VALVE GEAR.

Fig. 94 illustrates Joy's valve gear, as fitted to a large number of engines.

The fundamental principle of this gear is that eccentrics are entirely dispensed with, valve motion being obtained from a point in the connecting-rod, produced by a combination of two motions at right angles to each other, and by the various proportions in which these are combined, and by the positions in which the moving parts are set with regard to each other, it gives both the reversal of motion and the various degrees of expansion required. By utilising independently the





backward and forward action of the rod, due to the reciprocation of the piston, and combining this with the vibrating action of the rod, a movement results which is suitable to work the valves of engines allowing the use of any proportions of lap and lead desired, and giving an almost mathematically correct "cut off" for both sides of the piston, and for all points of expansion intermediately.

It will be observed (Fig. 94) that the main valve-lever is pinned to a link, one end of which is fastened to the connecting-rod, and the other end maintained in about the vertical position by a radius rod, which is fixed to the frame near to the leading axle. The centre or fulcrum of the valve-lever partaking of the vibrating movement of the connecting-rod, is carried in a curved slide.

From the upper end of the valve-lever motion is communicated direct to the valve by the valve-rod. It will thus be evident that by one revolution of the crank the lower end of the valve-lever will have imparted to it two different movements, one travelling in length in consequence of the stroke, the other up and down in consequence of the revolution of the crank, these movements differing as to time, and corresponding to the part of the movement of the valve required for lap and lead, and that part constituting the port opening for admission of steam.

The former of these is constant and unalterable, the latter is controllable by the angle at which the curved slide may be set by the driver. Fig. 95, p. 200, shows the actual opening of the valve and the cut-off for the various positions of the reversing gear screw or lever the foot-plate.

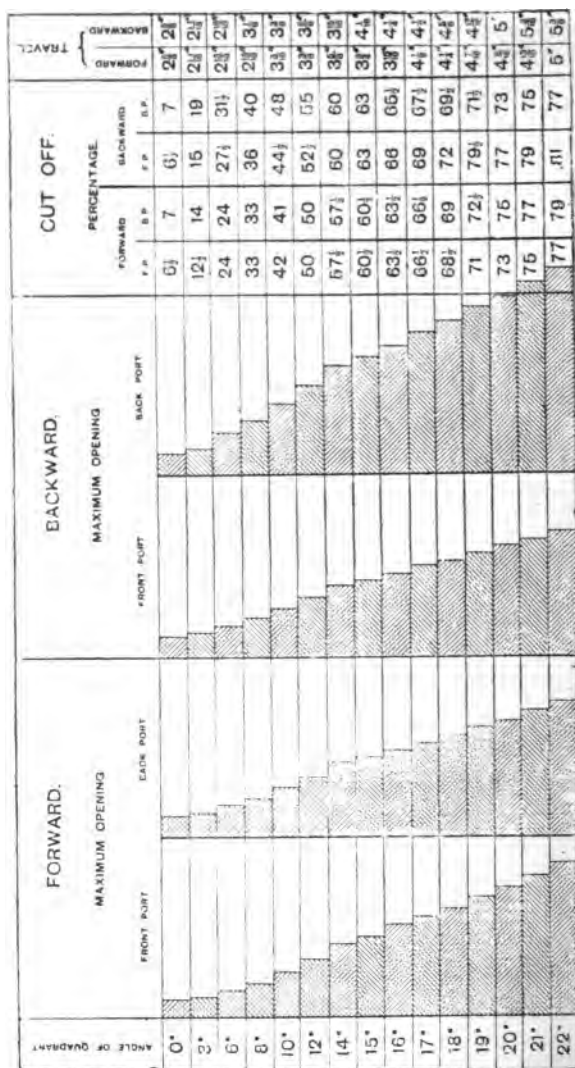


Fig. 95.—Joy's Valve Gear. Actual Result.

INDEX.

A DAMS, Mr. W., 149.
 "Agenoria," 29.
Allan, Mr. Alexander, 88, 98.
Allen, Mr. Horatio, 27.
American engines for England,
 81.
American engines, 181.
Arbroath and Forfar Railway,
 77.

BATTLE of the gauges, 72.
 Beyer, Peacock & Co., en-
 gines by, for Midland, 131;
 Metropolitan, 158; Mersey,
 160.
Birmingham and Gloucester en-
 gines, 47, 81.
Blenkinsop, 7.
Bloomer type, 105.
Bolton and Leigh Railway, 25.
Brighton engines, 124, 130.
Bristol and Exeter engines,
 107.
Broad gauge, introduced, 72; re-
 moved, 167.

Brunel, Mr., 72.
Bury, Mr. Edward, 40, 60, 61,
 69, 82.

CABRY, Mr. Henry, 52.
 Caledonian Railway, 136.
Carmichael & Co., 55.
Coal burning, 108.
Collision at Thornton, 51.
Compound engines not successful,
 128, 140.
"Cornwall," The, 99.
Crampton's patent, 92, 100.
Crewe works opened, 90.

DEAN, Mr. William, engines
 by, 167.
Dome, an advantage, 168.
Dübs & Co., engines by, 116.
Dundee and Newtyle, 55.

EIGHTY miles an hour, 140.

FATHER of the locomotive, 5.
Four-cylinder engines, 22,
185.

Four eccentrics, 62.

Forrester & Co., 63.

GIFFARD injector, 193.

Glasgow and South-Western
engines, 122.

Gooch, Sir Daniel, 73, 95.

Gooch, Mr. John V., 9.

Grand Junction Railway, 74,
89.

Great Eastern, 141, 174.

Great Southern and Western en-
gines, 170.

Great Western engines, 72, 78,
167.

Grasshopper springs, 46.

HACKWORTH, Mr. T., 22.

Haigh Foundry gear, 80.

Harrison, Mr. T. E., 76.

Hawthorn & Co., 47, 64, 185;
valve gear, 65.

"Hector," 79.

"Hercules," 57.

Hetton Colliery engines, 18.

High boilers, 106.

Holden, Mr., design, 141; liquid
fuel, 143.

Howe's link-motion, 87.

"Hurricane," 76.

INJECTOR, 110, 192.

Inside cylinders an advan-
tage, 140.

"Invicta," preserved at Ashford,
35.

JENNY LIND type, 103.

Johnson, Mr. S. W., en-
gines by, 126, 131, 161.

Joy's gear, 198.

KILLINGWORTH engines,
12, 14.

Kirtley, Mr. M., engines designed
by, 115, 116, 117, 119.

Kirtley, Mr. W., engines by,
154.

Kitson & Co., engines by, 126.

LANCASHIRE and Yorkshire
Railway, 160.

Leicester and Swannington Rail-
way opened, 43; engines, 44,
46, 50, 57, 59, 79.

Link-motion invented, 87.

Liquid fuel, 143.

"Liverpool," 1834, 61.

"Liverpool," 1848, 100.

Liverpool and Manchester Rail-
way, Rainhill trial, 30; opened,
36; engines, 31, 33, 37, 49,
57.

Locke, Mr., 74.

"Locomotion," 20.

London, Tilbury, and Southend
Railway, 156.

London and North-Western en-
gines, 90, 98, 100, 165.

London and Birmingham Rail-
way, 47.

London and South-Western Rail-
way, 91, 150.

Long boilers, 84.

MANCHESTER, Sheffield, and Lincolnshire Railway, 145 to London, 146.
 Marshall and Woods' report on Crewe and Wolverton engines, 106.
 McConnell, Mr., 83, 104, 105.
 Mersey engines, 160.
 Middleton Railway, 7.
 Midland engines, 114 — goods, 116, 131; mineral, 126; tank, 117; the latest "single," 161; the latest coupled, 134, 169; gradients, 163.

NEILSON & Co., engines built by, 113, 118, 121.
 Newcastle and Carlisle engines, 64.
 Nicholson, Mr. John, 45.
 North-Eastern engines, 147, 148
 North British engines, 160.
 North London engines, 156.
 North Midland engines, 84.

PARK, Mr., designs for North London engines, 156.
 Parker, Mr., designs for Manchester, Sheffield, and Lincolnshire engines, 145.
 Pearson, Mr., designs, 107.

RAILWAY race, 137, 139.
 Ramsbottom, Mr. John, 109.
 Reversing, by steam, 123; by air, 129.

SAND blast, the, 191.
 Sharp, Roberts & Co., 54, 70.
 Sharp, Stewart & Co., 169.
 South-Eastern engines, 154.
 South Kensington Museum, engines preserved at: "Rocket," 31; "Sanspareil," 34; "Agenorria," 29; "Puffing Billy," 10.
 Speed, high, 99, 101.
 Speed, highest ever attained, 108.
 Steam springs, 14.
 Stephenson, Mr. George, first engine, 13; Hetton engines, 18; engineer, Stockton and Darlington line, 19; drove "Northumbrian," 35; the "Comet," 44; the "Stephenson," 42.
 Stephenson & Co., engines by, 19, 23, 27, 30, 38, 59; "Standard," 67.
 Stirling, Mr. P., engines for Great Northern Railway, 138.
 Stirling, Mr. James, 122, 154.
 Stirling & Co., 78.
 Stockton and Darlington Railway opened, 19; engines, 21.
 Stroudley, engines by, 124, 129.

TANK ENGINE, 68 tons, 160.
 Tayleur & Co., 65.
 Ten-feet wheels, 76.
 Three-cylinder engines, 93.
 Four cylinders, 24, 183, 184.
 Trevithick, Mr. R., 5.

Trevithick, Mr. F., 96.

Tulk & Ley, Messrs., 92, 97.

UNION Foundry, Bolton, 107.

VALVE-GEAR, ancient, 45 ;
Forrester's, 63; Hawthorn's,
65 ; Roberts's, 64 ; Haigh
Foundry, 80 ; Howe's, 87 ;
Joy's, 198.

Vauclain Compound, 183.

"Velocipede," 98.

Vortex blast pipe, 162

"Vulcan," 66.

Vulcan Foundry, 69.

WEATHERBURN, Mr., 44.
Webb, Mr., latest designs,
165, 178 ; an impartial trial
necessary, 128.

Whistle, the first steam, 52.

Winby's design, 184.

Wilson, E. B. & Co., engines by,
103.

Wolverton, engines built at, 105,
111.

Woradell, Mr., designs for North-
Eastern engines, 148.

7, STATIONERS' HALL COURT, LONDON, E.C.
February, 1893.

A
CATALOGUE OF BOOKS

INCLUDING NEW AND STANDARD WORKS IN
ENGINEERING: CIVIL, MECHANICAL, AND MARINE;
ELECTRICITY AND ELECTRICAL ENGINEERING;
MINING, METALLURGY; ARCHITECTURE,
BUILDING, INDUSTRIAL AND DECORATIVE ARTS;
SCIENCE, TRADE AND MANUFACTURES;
AGRICULTURE, FARMING, GARDENING;
AUCTIONEERING, VALUING AND ESTATE AGENCY;
LAW AND MISCELLANEOUS.

PUBLISHED BY

CROSBY LOCKWOOD & SON.

MECHANICAL ENGINEERING, etc.

D. K. Clark's Pocket-Book for Mechanical Engineers.

THE MECHANICAL ENGINEER'S POCKET-BOOK OF TABLES, FORMULÆ, RULES AND DATA. A Handy Book of Reference for Daily Use in Engineering Practice. By D. KINNAR CLARK, M.Inst.C.E., Author of "Railway Machinery," "Tramways," &c. Second Edition, Revised and Enlarged. Small 8vo, 700 pages, 9s. bound in flexible leather covers, with rounded corners and gilt edges. *[Just published.]*

SUMMARY OF CONTENTS.

MATHEMATICAL TABLES.—MEASUREMENT OF SURFACES AND SOLIDS.—ENGLISH WEIGHTS AND MEASURES.—FRENCH METRIC WEIGHTS AND MEASURES.—FOREIGN WEIGHTS AND MEASURES.—MONEYS.—SPECIFIC GRAVITY. WEIGHT AND VOLUME.—MANUFACTURED METALS.—STEEL PIPES.—BOLTS AND NUTS.—SUNDRY ARTICLES IN WROUGHT AND CAST IRON, COPPER, BRASS, LEAD, TIN, ZINC.—STRENGTH OF MATERIALS.—STRENGTH OF TIMBER.—STRENGTH OF CAST IRON.—STRENGTH OF WROUGHT IRON.—STRENGTH OF STEEL.—TENSILE STRENGTH OF COPPER, LEAD, ETC.—RESISTANCE OF STONES AND OTHER BUILDING MATERIALS.—RIVETED JOINTS IN BOILER PLATES.—BOILER SHELLS.—WIRE ROPES AND HEMP ROPES.—CHAINS AND CHAIN CABLES.—FRAMING.—HARDNESS OF METALS, ALLOYS AND STONES.—LABOUR OF ANIMALS.—MECHANICAL PRINCIPLES.—GRAVITY AND FALL OF BODIES.—ACCELERATING AND RETARDING FORCES.—MILL GEARING, SHAFTING, ETC.—TRANSMISSION OF MOTIVE POWER.—HEAT.—COMBUSTION: FUELS.—WARMING, VENTILATION, COOKING STOVES.—STEAM.—STEAM ENGINES AND BOILERS.—RAILWAYS.—TRAMWAYS.—STEAM SHIPS.—PUMPING STEAM ENGINES AND PUMPS.—COAL GAS, GAS ENGINES, ETC.—AIR IN MOTION.—COMPRESSED AIR.—HOT AIR ENGINES.—WATER POWER.—SPEED OF CUTTING TOOLS.—COLOURS.—ELECTRICAL ENGINEERING.

*** * * OPINIONS OF THE PRESS.**

"Mr. Clark manifests what is an innate perception of what is likely to be useful in a pocket-book, and he is really unrivalled in the art of condensation. . . . It is very difficult to hit upon any mechanical engineering subject concerning which this work supplies no information, and the excellent index at the end adds to its utility. In one word, it is an exceedingly handy and efficient tool, possessed of which the engineer will be saved many a wearisome calculation, or yet more wearisome hunt through various text-books and treatises, and, as such, we can heartily recommend it to our readers, who must not run away with the idea that Mr. Clark's Pocket-book is only Molesworth in another form. On the contrary, each contains what is not to be found in the other; and Mr. Clark takes more room and deals at more length with many subjects than Molesworth possibly could."—*The Engineer*, Sept 16th, 1892.

"Just the kind of work that practical men require to have near to them."—*English Mechanic*.

MR. HUTTON'S PRACTICAL HANDBOOKS.

Handbook for Works' Managers.

THE WORKS' MANAGER'S HANDBOOK OF MODERN RULES, TABLES, AND DATA. For Engineers, Millwrights, and Boiler Makers; Tool Makers, Machinists, and Metal Workers; Iron and Brass-Founders, &c. By W. S. HUTTON, Civil and Mechanical Engineer, Author of "The Practical Engineer's Handbook." Fourth Edition, carefully Revised and partly Re-written. In One handsome Volume, medium 8vo, price 15s. strongly bound.

✎ The Author having compiled Rules and Data for his own use in a great variety of modern engineering work, and having found his notes extremely useful, decided to publish them—revised to date—believing that a practical work, suited to the DAILY REQUIREMENTS of MODERN ENGINEERS, would be favourably received.

In the Fourth Edition the First Section has been re-written and improved by the addition of numerous Illustrations and new matter relating to STEAM ENGINES and GAS ENGINES. The Second Section has been enlarged and Illustrated, and throughout the book a great number of emendations and alterations have been made, with the object of rendering the book more generally useful.

** OPINIONS OF THE PRESS.

"The author treats every subject from the point of view of one who has collected workshop notes for application in workshop practice, rather than from the theoretical or literary aspect. The volume contains a great deal of that kind of information which is gained only by practical experience, and is seldom written in books."—*Engineer*.

"The volume is an exceedingly useful one, brimful with engineers' notes, memoranda, and rules, and well worthy of being on every mechanical engineer's bookshelf."—*Mechanical World*.

"A formidable mass of facts and figures, readily accessible through an elaborate index. . . . Such a volume will be found absolutely necessary as a book of reference in all sorts of 'works' connected with the metal trades."—*Ryland's Iron Trades Circular*.

"Brimful of useful information, stated in a concise form, Mr. Hutton's books have met a pressing want among engineers. The book must prove extremely useful to every practical man possessing a copy."—*Practical Engineer*.

New Manual for Practical Engineers.

THE PRACTICAL ENGINEER'S HAND-BOOK. Comprising a Treatise on Modern Engines and Boilers: Marine, Locomotive and Stationary. And containing a large collection of Rules and Practical Data relating to recent Practice in Designing and Constructing all kinds of Engines, Boilers, and other Engineering work. The whole constituting a comprehensive Key to the Board of Trade and other Examinations for Certificates of Competency in Modern Mechanical Engineering. By WALTER S. HUTTON, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook for Engineers," &c. With upwards of 370 Illustrations. Fourth Edition, Revised, with Additions. Medium 8vo, nearly 500 pp., price 18s. Strongly bound.

✎ This work is designed as a companion to the Author's "WORKS' MANAGER'S HAND-BOOK." It possesses many new and original features, and contains, like its predecessor, a quantity of matter not originally intended for publication, but collected by the author for his own use in the construction of a great variety of MODERN ENGINEERING WORK.

The information is given in a condensed and concise form, and is illustrated by upwards of 370 Woodcuts; and comprises a quantity of tabulated matter of great value to all engaged in designing, constructing, or estimating for ENGINES, BOILERS, and OTHER ENGINEERING WORK.

** OPINIONS OF THE PRESS.

"We have kept it at hand for several weeks, referring to it as occasion arose, and we have not on a single occasion consulted its pages without finding the information of which we were in quest."—*Athenaeum*.

"A thoroughly good practical handbook, which no engineer can go through without learning something that will be of service to him."—*Marine Engineer*.

"The author has collected together a surprising quantity of rules and practical data, and has shown much judgment in the selections he has made. . . . There is no doubt that this book is one of the most useful of its kind published, and will be a very popular compendium."—*Engineer*.

"A mass of information, set down in simple language, and in such a form that it can be easily referred to at any time. The matter is uniformly good and well chosen and is greatly elucidated by the illustrations. The book will find its way on to most engineers' shelves, where it will rank as one of the most useful books of reference."—*Practical Engineer*.

"Full of useful information and should be found on the office shelf of all practical engineers."—*English Mechanic*.

MR. HUTTON'S PRACTICAL HANDBOOKS—continued.

Practical Treatise on Modern Steam-Boilers.

STEAM-BOILER CONSTRUCTION. A Practical Handbook for Engineers, Boiler-Makers, and Steam Users. Containing a large Collection of Rules and Data relating to Recent Practice in the Design, Construction, and Working of all Kinds of Stationary, Locomotive, and Marine Steam-Boilers. By WALTER S. HUTTON, Civil and Mechanical Engineer, Author of "The Works' Manager's Handbook," "The Practical Engineer's Handbook," &c. With upwards of 300 Illustrations. Second Edition. Medium 8vo, 13s. cloth. [Just published.]

THIS WORK is issued in continuation of the Series of Handbooks written by the Author, viz:—"THE WORKS' MANAGERS' HANDBOOK" and "THE PRACTICAL ENGINEER'S HANDBOOK," which are so highly appreciated by Engineers for the practical nature of their information; and is consequently written in the same style as those works.

The Author believes that the concentration, in a convenient form for easy reference, of such a large amount of thoroughly practical information on Steam-Boilers, will be of considerable service to those for whom it is intended, and he trusts the book may be deemed worthy of as favourable a reception as has been accorded to its predecessors.

** OPINIONS OF THE PRESS.

"Every detail, both in boiler design and management, is clearly laid before the reader. The volume shows that boiler construction has been reduced to the condition of one of the most exact sciences; and such a book is of the utmost value to, the *fin de siècle* Engineer and Works' Manager."—*Marine Engineer*.

"There has long been room for a modern handbook on steam boilers; there is not that room now, because Mr. Hutton has filled it. It is a thoroughly practical book for those who are occupied in the construction, design, selection, or use of boilers."—*Engineer*.

"The book is of so important and comprehensive a character that it must find its way into the libraries of everyone interested in boiler using or boiler manufacture if they wish to be thoroughly informed. We strongly recommend the book for the intrinsic value of its contents."—*Machinery Market*.

"The value of this book can hardly be over-estimated. The author's rules, formulæ, &c., are all very fresh, and it is impossible to turn to the work and not find what you want. No practical engineer should be without it."—*Colliery Guardian*.

Hutton's "Modernised Templeton."

THE PRACTICAL MECHANICS' WORKSHOP COMPANION. Comprising a great variety of the most useful Rules and Formulæ in Mechanical Science, with numerous Tables of Practical Data and Calculated Results for Facilitating Mechanical Operations. By WILLIAM TEMPLETON, Author of "The Engineer's Practical Assistant," &c. &c. Sixteenth Edition, Revised, Modernised, and considerably Enlarged by WALTER S. HUTTON, C.E., Author of "The Works' Manager's Handbook," &c. Fcap. 8vo, nearly 500 pp., with 8 Plates and upwards of 250 Illustrative Diagrams, 6s., strongly bound for workshop or pocket wear and tear.

** OPINIONS OF THE PRESS.

"In its modernised form Hutton's 'Templeton' should have a wide sale, for it contains much valuable information which the mechanic will often find of use, and not a few tables and notes which he might look for in vain in other works. This modernised edition will be appreciated by all who have learned to value the original editions of 'Templeton.'"—*English Mechanic*.

"It has met with great success in the engineering workshop, as we can testify; and there are a great many men who, in a great measure, owe their rise in life to this little book."—*Building News*.

"This familiar text-book—well known to all mechanics and engineers—is of essential service to the every-day requirements of engineers, millwrights, and the various trades connected with engineering and building. The new modernised edition is worth its weight in gold."—*Building News*. (Second Notice.)

"This well-known and largely used book contains information, brought up to date, of the sort so useful to the foreman and draughtsman. So much fresh information has been introduced as to constitute it practically a new book. It will be largely used in the office and workshop."—*Mechanical World*.

Templeton's Engineer's and Machinist's Assistant.

THE ENGINEER'S, MILLWRIGHT'S, and MACHINIST'S PRACTICAL ASSISTANT. A collection of Useful Tables, Rules and Data. By WILLIAM TEMPLETON. 7th Edition, with Additions. 18mo, 2s. 6d. cloth.

"Occupies a foremost place among books of this kind. A more suitable present to an apprentice to any of the mechanical trades could not possibly be made."—*Building News*.

"A deservedly popular work. It should be in the 'drawer' of every mechanic."—*English Mechanic*.

Foley's Reference Book for Mechanical Engineers.

THE MECHANICAL ENGINEER'S REFERENCE BOOK,
for Machine and Boiler Construction. In Two Parts. Part I. GENERAL
ENGINEERING DATA. Part II. BOILER CONSTRUCTION. With 51 Plates and
numerous Illustrations. By NELSON FOLEY, M.I.N.A. Folio, £5 5s. half-
bound. [Just published.]

SUMMARY OF CONTENTS.

PART I.

MEASURES.—CIRCUMFERENCES AND
AREAS, &c., SQUARES, CUBES, FOURTH
POWERS.—SQUARE AND CUBE ROOTS.—
SURFACE OF TUBES—RECIPROCALLS.—
LOGARITHMS.—MENSURATION.—SPEC-
IFIC GRAVITIES AND WEIGHTS.—
WORK AND POWER.—HEAT.—COMBUS-
TION.—EXPANSION AND CONTRACTION.
—EXPANSION OF GASES.—STEAM.—
STATIC FORCES.—GRAVITATION AND
ATTRACTION.—MOTION AND COMPUTA-
TION OF RESULTING FORCES.—ACCUMU-
LATED WORK.—CENTRE AND RADIUS

OF GYRATION.—MOMENT OF INERTIA.
—CENTRE OF OSCILLATION.—ELEC-
TRICITY.—STRENGTH OF MATERIALS.
—ELASTICITY.—TEST SHEETS OF
METALS.—FRICTION.—TRANSMISSION
OF POWER.—FLOW OF LIQUIDS.—FLOW
OF GASES.—AIR PUMPS, SURFACE CON-
DENSERS, &c.—SPEED OF STEAMSHIPS.
—PROPELLERS.—CUTTING TOOLS.—
FLANGES.—COPPER SHEETS AND
TUBES.—SCREWS, NUTS, BOLT HEADS,
&c.—VARIOUS RECIPES AND MISCEL-
LANEOUS MATTER.

WITH DIAGRAMS FOR VALVE-GEAR, BELTING AND ROPES, DISCHARGE AND
SUCTION PIPES, SCREW PROPELLERS, AND COPPER PIPES.

PART II.

TREATING OF, POWER OF BOILERS.—
USEFUL RATIOS.—NOTES ON CON-
STRUCTION.—CYLINDRICAL BOILER
SHELLS.—CIRCULAR FURNACES.—
FLAT PLATES.—STAYS.—GIRDERS.—
SCREWS.—HYDRAULIC TESTS.—

RIVETING.—BOILER SETTING, CHIM-
NEYS, AND MOUNTINGS.—FUELS, &c.—
EXAMPLES OF BOILERS AND SPEEDS OF
STEAMSHIPS.—NOMINAL AND NORMAL
HORSE POWER.

WITH DIAGRAMS FOR ALL BOILER CALCULATIONS AND DRAWINGS OF MANY
VARIETIES OF BOILERS.

. OPINIONS OF THE PRESS.

"This appears to be a work for which there should be a large demand on the part of mechanical engineers. It is no easy matter to compile a book of this class, and the labour involved is enormous, particularly when—as the author informs us—the majority of the tables and diagrams have been specially prepared for the work. The diagrams are exceptionally well executed, and generally constructed on the method adopted in a previous work by the same author. . . . The tables are very numerous, and deal with a greater variety of subjects than will generally be found in a work of this kind; they have evidently been compiled with great care and are unusually complete. All the information given appears to be well up to date. . . . It would be quite impossible within the limits at our disposal to even enumerate all the subjects treated; it should, however, be mentioned that the author does not confine himself to a mere bald statement of formulae and laws, but in very many instances shows succinctly how these are derived. . . . The latter part of the book is devoted to diagrams relating to Boiler Construction, and to nineteen beautifully-executed plates of working drawings of boilers and their details. As samples of how such drawings should be got out, they may be cordially recommended to the attention of all young, and even some elderly, engineers. . . . Altogether the book is one which every mechanical engineer may, with advantage to himself add to his library."—*Industries*.

"Mr. Foley is well fitted to compile such a work. . . . The diagrams are a great feature of the work. . . . Regarding the whole work, it may be very fairly stated that Mr. Foley has produced a volume which will undoubtedly fulfil the desire of the author and become indispensable to all mechanical engineers."—*Marine Engineer*.

"We have carefully examined this work, and pronounce it a most excellent reference book for the use of marine engineers."—*Journal of American Society of Naval Engineers*.

"A veritable monument of industry on the part of Mr. Foley, who has succeeded in producing what is simply invaluable to the engineering profession."—*Steamship*.

Coal and Speed Tables.

A POCKET BOOK OF COAL AND SPEED TABLES, for
Engineers and Steam-users. By NELSON FOLEY, Author of "The Mechanical
Engineer's Reference Book." Pocket-size, 3s. 6d. cloth.

"These tables are designed to meet the requirements of every-day use; they are of sufficient scope for most practical purposes, and may be commended to engineers and users of steam."—*Iron*.

"This pocket-book well merits the attention of the practical engineer. Mr. Foley has compiled a very useful set of tables, the information contained in which is frequently required by engineers, coal consumers and users of steam."—*Iron and Coal Trades Review*.

Steam Engine.

TEXT-BOOK ON THE STEAM ENGINE. With a Supplement on Gas Engines, and PART II. ON HEAT ENGINES. By T. M. GOODEVE, M.A., Barrister-at-Law, Professor of Mechanics at the Normal School of Science and the Royal School of Mines; Author of "The Principles of Mechanics," "The Elements of Mechanism," &c. Eleventh Edition, Enlarged. With numerous Illustrations. Crown 8vo, 6s. cloth.

"Professor Goodeve has given us a treatise on the steam engine which will bear comparison with anything written by Huxley or Maxwell, and we can award it no higher praise."—*Engineer*.

"Mr. Goodeve's text-book is a work of which every young engineer should possess himself."—*Mining Journal*.

"Essentially practical in its aim. The manner of exposition leaves nothing to be desired."—*Scotsman*.

Gas Engines.

ON GAS-ENGINES. Being a Reprint, with some Additions, of the Supplement to the *Text-book on the Steam Engine*, by T. M. GOODEVE, M.A. Crown 8vo, 2s. 6d. cloth.

"Like all Mr. Goodeve's writings, the present is no exception in point of general excellence. It is a valuable little volume."—*Mechanical World*.

Steam Engine Design.

THE STEAM ENGINE: A Practical Manual for Draughtsmen, Designers, and Constructors. Translated from the German of HERMANN HAEDER; Revised and Adapted to English Practice by H. H. P. POWLES, A.M.I.C.E., Translator of Kick's Treatise on "Flour Manufacture." Upwards of 1,000 Diagrams. Crown 8vo, cloth. [In the press.]

Steam Boilers.

A TREATISE ON STEAM BOILERS: Their Strength, Construction, and Economical Working. By ROBERT WILSON, C.E. Fifth Edition. 12mo, 6s. cloth.

"The best treatise that has ever been published on steam boilers."—*Engineer*.

"The author shows himself perfect master of his subject, and we heartily recommend all employing steam power to possess themselves of the work."—*Ryland's Iron Trade Circular*.

Boiler Chimneys.

BOILER AND FACTORY CHIMNEYS: Their Draught-Power and Stability. With a Chapter on Lightning Conductors. By ROBERT WILSON, A.I.C.E., Author of "A Treatise on Steam Boilers," &c. Second Edition. Crown 8vo, 3s. 6d. cloth.

"Full of useful information, definite in statement, and thoroughly practical in treatment."—

The Local Government Chronicle.

"A valuable contribution to the literature of scientific building."—*The Builder*.

Boiler Making.

THE BOILER-MAKER'S READY RECKONER & ASSISTANT. With Examples of Practical Geometry and Templating, for the Use of Platers, Smiths and Riveters. By JOHN COURTNEY, Edited by D. K. CLARK, M.I.C.E. Third Edition, 480 pp., with 140 Illusts. Fcap. 8vo, 7s. half-bound.

"A most useful work. . . . No workman or apprentice should be without this book."—*Iron Trade Circular*.

"Boiler-makers will readily recognise the value of this volume. . . . The tables are clearly printed, and so arranged that they can be referred to with the greatest facility, so that it cannot be doubted that they will be generally appreciated and much used."—*Mining Journal*.

Locomotive Engine Development.

THE LOCOMOTIVE ENGINE AND ITS DEVELOPMENT. A Popular Treatise on the Gradual Improvements made in Railway Engines between the Years 1803 and 1892. By CLEMENT E. STRETTON, C.E., Author of "Safe Railway Working," &c. Second Edition, Revised and much Enlarged. With 94 Illustrations. Crown 8vo, 3s. 6d. cloth. [Just published.]

"Students of railway history and all who are interested in the evolution of the modern locomotive will find much to attract and entertain in this volume."—*The Times*.

"The volume cannot fail to be popular, because it contains, in a condensed and readable form, a great deal of just the kind of information that multitudes of people want."—*Engineer*.
The author of this work is well known to the railway world as one who has long taken a great interest in everything pertaining thereto. No one probably has a better knowledge of the history and development of the locomotive. It is with much pleasure we welcome the volume before us, which, taken as a whole, is most interesting, and should be of value to all connected with the railway system of this country, as a book of reference."—*Nature*.

Fire Engineering.

FIRES, FIRE-ENGINES, AND FIRE-BRIGADES. With a History of Fire-Engines, their Construction, Use, and Management; Remarks on Fire-Proof Buildings, and the Preservation of Life from Fire; Statistics of the Fire Appliances in English Towns; Foreign Fire Systems; Hints on Fire-Brigades, &c. &c. By CHARLES F. T. YOUNG, C.E. With numerous Illustrations. 544 pp., demy 8vo, £1 4s. cloth.

To such of our readers as are interested in the subject of fires and fire apparatus, we can most heartily commend this book. It is really the only English work we now have upon the subject"—*Engineering*.

Estimating for Engineering Work, &c.

ENGINEERING ESTIMATES, COSTS AND ACCOUNTS:

A Guide to Commercial Engineering. With numerous Examples of Estimates and Costs of Millwright Work, Miscellaneous Productions, Steam Engines and Steam Boilers; and a Section on the Preparation of Costs Accounts. By A GENERAL MANAGER. Demy 8vo, 12s. cloth.

"This is an excellent and very useful book, covering subject-matter in constant requisition in every factory and workshop. . . . The book is invaluable, not only to the young engineer, but also to the estimate department of every works."—*Builder*.

"We accord the work unqualified praise. The information is given in a plain, straightforward manner, and bears throughout evidence of the intimate practical acquaintance of the author with every phase of commercial engineering."—*Mechanical World*

Engineering Construction.

PATTERN-MAKING: A Practical Treatise, embracing the Main

Types of Engineering Construction, and including Gearing, both Hand and Machine made, Engine Work, Sheaves and Pulleys, Pipes and Columns, Screws, Machine Parts, Pumps and Cocks, the Moulding of Patterns in Loam and Greensand, &c., together with the methods of Estimating the weight of Castings; to which is added an Appendix of Tables for Workshop Reference. By A FOREMAN PATTERN MAKER. With upwards of 370 Illustrations. Crown 8vo, 7s. 6d. cloth.

"A well-written technical guide, evidently written by a man who understands and has practised what he has written about. . . . We cordially recommend it to engineering students, young journeymen, and others desirous of being initiated into the mysteries of pattern-making."—*Builder*.

"More than 370 illustrations help to explain the text, which is, however, always clear and explicit, thus rendering the work an excellent *vade mecum* for the apprentice who desires to become master of his trade."—*English Mechanic*.

Dictionary of Mechanical Engineering Terms.

LOCKWOOD'S DICTIONARY OF TERMS USED IN THE

PRACTICE OF MECHANICAL ENGINEERING, embracing those current in the Drawing Office, Pattern Shop, Foundry, Fitting, Turning, Smith's and Boiler Shops, &c. &c. Comprising upwards of 6,000 Definitions. Edited by A FOREMAN PATTERN-MAKER, Author of "Pattern Making." Second Edition, Revised, with Additions. Crown 8vo, 7s. 6d. cloth. [*Just published.*]

"Just the sort of handy dictionary required by the various trades engaged in mechanical engineering. The practical engineering pupil will find the book of great value in his studies, and every foreman engineer and mechanic should have a copy."—*Building News*.

"One of the most useful books which can be presented to a mechanic or student."—*English Mechanic*.

"Not merely a dictionary, but, to a certain extent, also a most valuable guide. It strikes us as a happy idea to combine with a definition of the phrase useful information on the subject of which it treats."—*Machinery A.arket*.

Mill Gearing.

TOOTHED GEARING: A Practical Handbook for Offices and

Workshops. By A FOREMAN PATTERN MAKER, Author of "Pattern Making,"

"Lockwood's Dictionary of Mechanical Engineering Terms," &c. With 184 Illustrations. Crown 8vo, 6s. cloth. [*Just published.*]

SUMMARY OF CONTENTS.

CHAP. I. PRINCIPLES.—II. FORMATION OF TOOTH PROFILES.—III. PROPORTIONS OF TEETH.—IV. METHODS OF MAKING TOOTH FORMS.—V. INVOLUTE TEETH.—VI. SOME SPECIAL TOOTH FORMS.—VII. BEVEL WHEELS.—VIII. SCREW GEARS.—IX. WORM GEARS.—X. HELICAL WHEELS.—XI.

SKREW BEVELS.—XII. VARIABLE AND OTHER GEARS.—XIII. DIAMETRICAL PITCH.—XIV. THE ODONTOGRAPH.—XV. PATTERN GEARS.—XVI. MACHINE MOULDING GEARS.—XVII. MACHINE CUT GEARS.—XVIII. PROPORTION OF WHEELS.

"We must give the book our unqualified praise for its thoroughness of treatment, and we can heartily recommend it to all interested as the most practical book on the subject yet written."—*Mechanical World*.

Stone-working Machinery.

STONE-WORKING MACHINERY, and the Rapid and Economical Conversion of Stone. With Hints on the Arrangement and Management of Stone Works. By M. POWIS BALE, M.I.M.E. With Illusts. Crown 8vo, 9s.

"The book should be in the hands of every mason or student of stone-work."—*Colliery Guardian*.

"A capital handbook for all who manipulate stone for building or ornamental purposes."—*Machinery Market*.

Pump Construction and Management.

PUMPS AND PUMPING: A Handbook for Pump Users. Being Notes on Selection, Construction and Management. By M. POWIS BALE, M.I.M.E., Author of "Woodworking Machinery," "Saw Mills," &c. Second Edition, Revised. Crown 8vo, 2s. 6d. cloth. [Just published.]

"The matter is set forth as concisely as possible. In fact, condensation rather than diffuseness has been the author's aim throughout; yet he does not seem to have omitted anything likely to be of use."—*Journal of Gas Lighting*.

"Thoroughly practical and simply and clearly written."—*Glasgow Herald*.

Milling Machinery, etc.

MILLING MACHINES AND PROCESSES: A Practical Treatise on Shaping Metals by Rotary Cutters, including Information on Making and Grinding the Cutters. By PAUL N. HASLUCK, Author of "Lathe-work," "Handybooks for Handicrafts," &c. With upwards of 300 Engravings, including numerous Drawings by the Author. Large crown 8vo, 352 pages, 12s. 6d. cloth.

"A new departure in engineering literature. . . . We can recommend this work to all interested in milling machines; it is what it professes to be—a practical treatise."—*Engineer*.

"A capital and reliable book, which will no doubt be of considerable service, both to those who are already acquainted with the process as well as to those who contemplate its adoption."—*Industries*.

Turning.

LATHE-WORK: A Practical Treatise on the Tools, Appliances, and Processes employed in the Art of Turning. By PAUL N. HASLUCK. Fourth Edition, Revised and Enlarged. Cr. 8vo, 5s. cloth.

"Written by a man who knows, not only how work ought to be done, but who also knows how to do it, and how to convey his knowledge to others. To all turners this book would be valuable."—*Engineering*.

"We can safely recommend the work to young engineers. To the amateur it will simply be invaluable. To the student it will convey a great deal of useful information."—*Engineer*.

Screw-Cutting.

SCREW THREADS: And Methods of Producing Them. With Numerous Tables, and complete directions for using Screw-Cutting Lathes. By PAUL N. HASLUCK, Author of "Lathe-Work," &c. With Seventy-four Illustrations. Third Edition, Revised and Enlarged. Waistcoat-pocket size, 1s. 6d. cloth.

"Full of useful information, hints and practical criticism. Taps, dies and screwing-tools generally are illustrated and their action described."—*Mechanical World*.

"It is a complete compendium of all the details of the screw cutting lathe; in fact a *multum in parvo* on all the subjects it treats upon."—*Carpenter and Builder*.

Smith's Tables for Mechanics, etc.

TABLES, MEMORANDA, AND CALCULATED RESULTS, FOR MECHANICS, ENGINEERS, ARCHITECTS, BUILDERS, etc. Selected and Arranged by FRANCIS SMITH. Fifth Edition, thoroughly Revised and Enlarged, with a New Section of ELECTRICAL TABLES, FORMULÆ, and MEMORANDA. Waistcoat-pocket size, 1s. 6d. limp leather.

"It would, perhaps, be as difficult to make a small pocket-book's selection of notes and formulae to suit ALL engineers as it would be to make a universal medicine; but Mr. Smith's waistcoat-pocket collection may be looked upon as a successful attempt."—*Engineer*.

"The best example we have ever seen of 270 pages of useful matter packed into the dimensions of a card-case."—*Building News*. "A veritable pocket treasury of knowledge."—*Iron*.

French-English Glossary for Engineers, etc.

A POCKET GLOSSARY of TECHNICAL TERMS: ENGLISH-FRENCH, FRENCH-ENGLISH; with Tables suitable for the Architectural, Engineering, Manufacturing and Nautical Professions. By JOHN JAMES FLETCHER, Engineer and Surveyor. Second Edition, Revised and Enlarged, 200 pp. Waistcoat-pocket size, 1s. 6d. limp leather.

"It is a very great advantage for readers and correspondents in France and England to have so large a number of the words relating to engineering and manufacturers collected in a limp, thin volume. The little book will be useful both to students and travellers."—*Architect*.

"The glossary of terms is very complete, and many of the tables are new and well arranged. We cordially commend the book."—*Mechanical World*.

Portable Engines.

THE PORTABLE ENGINE; ITS CONSTRUCTION AND MANAGEMENT. A Practical Manual for Owners and Users of Steam Engines generally. By WILLIAM DYSON WANSBROUGH. With 90 illustrations. Crown 8vo, 3s. 6d. cloth.

"This is a work of value to those who use steam machinery. . . . Should be read by every one who has a steam engine, on a farm or elsewhere."—*Mark Lane Express*.

"We cordially commend this work to buyers and owners of steam engines, and to those who have to do with their construction or use."—*Timber Trades Journal*.

"Such a general knowledge of the steam engine as Mr. Wansbrough furnishes to the reader should be acquired by all intelligent owners and others who use the steam engine."—*Building News*.

"An excellent text-book of this useful form of engine, which describes with all necessary minuteness the details of the various devices. . . . The Hints to Purchasers contain a good deal of commonsense and practical wisdom."—*English Mechanic*.

Iron and Steel.

"IRON AND STEEL": A Work for the Forge, Foundry, Factory, and Office. Containing ready, useful, and trustworthy information for Iron-masters and their Stock-takers; Managers of Bar, Rail, Plate, and Sheet Rolling Mills; Iron and Metal Founders; Iron Ship and Bridge Builders; Mechanical, Mining, and Consulting Engineers; Architects, Contractors, Builders, and Professional Draughtsmen. By CHARLES HOARE, Author of "The Slide Rule," &c. Eighth Edition, Revised throughout and considerably Enlarged. 32mo, 6s. leather.

"For comprehensiveness the book has not its equal."—*Iron*.

"One of the best of the pocket books."—*English Mechanic*.

"We cordially recommend this book to those engaged in considering the details of all kinds of iron and steel works."—*Naval Science*.

Elementary Mechanics.

CONDENSED MECHANICS. A Selection of Formulæ, Rules, Tables, and Data for the Use of Engineering Students, Science Classes, &c. In Accordance with the Requirements of the Science and Art Department. By W. G. CRAWFORD HUGHES, A.M.I.C.E. Crown 8vo, 2s. 6d. cloth.

"The book is well fitted for those who are either confronted with practical problems in their work, or are preparing for examination and wish to refresh their knowledge by going through their formulæ again."—*Marine Engineer*.

"It is well arranged, and well adapted to meet the wants of those for whom it is intended."—*Railway News*.

Steam.

THE SAFE USE OF STEAM. Containing Rules for Un-professional Steam-users. By an ENGINEER. Sixth Edition. Sewed, 6d.

"If steam-users would but learn this little book by heart, boiler explosions would become sensations by their rarity."—*English Mechanic*.

Warming.

HEATING BY HOT WATER; with Information and Suggestions on the best Methods of Heating Public, Private and Horticultural Buildings. By WALTER JONES. With upwards of 50 illustrations. Crown 8vo, 2s. cloth.

"We confidently recommend all interested in heating by hot water to secure a copy of this valuable little treatise."—*The Plumber and Decorator*.

THE POPULAR WORKS OF MICHAEL REYNOLDS

("THE ENGINE DRIVER'S FRIEND").

Locomotive-Engine Driving.

LOCOMOTIVE-ENGINE DRIVING: A Practical Manual for Engineers in charge of Locomotive Engines. By MICHAEL REYNOLDS, Member of the Society of Engineers, formerly Locomotive Inspector L. B. and S. C. R. Eighth Edition. Including a Key to the LOCOMOTIVE ENGINE. With Illustrations and Portrait of Author. Crown 8vo, 4s. 6d. cloth.

"Mr. Reynolds has supplied a want, and has supplied it well. We can confidently recommend the book, not only to the practical driver, but to everyone who takes an interest in the performance of locomotive engines."—*The Engineer*.

"Mr. Reynolds has opened a new chapter in the literature of the day. This admirable practical treatise, of the practical utility of which we have to speak in terms of warm commendation."—*Athenaeum*.

"Evidently the work of one who knows his subject thoroughly."—*Railway Service Gazette*.

"Were the cautions and rules given in the book to become part of the every-day working of our engine-drivers, we might have fewer distressing accidents to deplore."—*Scotsman*.

Stationary Engine Driving.

STATIONARY ENGINE DRIVING: A Practical Manual for Engineers in charge of Stationary Engines. By MICHAEL REYNOLDS. Fourth Edition, Enlarged. With Plates and Woodcuts. Crown 8vo, 4s. 6d. cloth.

"The author is thoroughly acquainted with his subjects, and his advice on the various points treated is clear and practical. . . . He has produced a manual which is an exceedingly useful one for the class for whom it is specially intended."—*Engineering*.

"Our author leaves no stone unturned. He is determined that his readers shall not only know something about the stationary engine, but all about it."—*Engineer*.

"An engineman who has mastered the contents of Mr. Reynolds's book will require but little actual experience with boilers and engines before he can be trusted to look after them."—*English Mechanic*.

The Engineer, Fireman, and Engine-Boy.

THE MODEL LOCOMOTIVE ENGINEER, FIREMAN, and ENGINE-BOY. Comprising a Historical Notice of the Pioneer Locomotive Engines and their Inventors. By MICHAEL REYNOLDS. With numerous Illustrations and a fine Portrait of George Stephenson. Crown 8vo, 4s. 6d. cloth.

"From the technical knowledge of the author it will appeal to the railway man of to-day more forcibly than anything written by Dr. Smiles. . . . The volume contains information of a technical kind, and facts that every driver should be familiar with."—*English Mechanic*.

"We should be glad to see this book in the possession of everyone in the kingdom who has ever laid, or is to lay, hands on a locomotive engine."—*Iron*.

Continuous Railway Brakes.

CONTINUOUS RAILWAY BRAKES: A Practical Treatise on the several Systems in Use in the United Kingdom; their Construction and Performance. With copious Illustrations and numerous Tables. By MICHAEL REYNOLDS. Large crown 8vo, 9s. cloth.

"A popular explanation of the different brakes. It will be of great assistance in forming public opinion, and will be studied with benefit by those who take an interest in the brake."—*English Mechanic*.

"Written with sufficient technical detail to enable the principle and relative connection of the various parts of each particular brake to be readily grasped."—*Mechanical World*.

Engine-Driving Life.

ENGINE-DRIVING LIFE: Stirring Adventures and Incidents in the Lives of Locomotive-Engine Drivers. By MICHAEL REYNOLDS. Second Edition, with Additional Chapters. Crown 8vo, 2s. cloth.

"From first to last perfectly fascinating. Wilkie Collins's most thrilling conceptions are thrown into the shade by true incidents, endless in their variety, related in every page."—*North British Mail*.

"Anyone who wishes to get a real insight into railway life cannot do better than read 'Engine-Driving Life' for himself; and if he once take it up he will find that the author's enthusiasm and real love of the engine-driving profession will carry him on till he has read every page."—*Saturday Review*.

Pocket Companion for Enginemen.

THE ENGINEMAN'S POCKET COMPANION AND PRACTICAL EDUCATOR FOR ENGINEMEN, BOILER ATTENDANTS, AND MECHANICS. By MICHAEL REYNOLDS. With Forty-five Illustrations and numerous Diagrams. Second Edition, Revised. Royal 18mo, 3s. 6d., strongly bound for pocket wear.

"This admirable work is well suited to accomplish its object, being the honest workmanship of a competent engineer."—*Glasgow Herald*.

"A most meritorious work, giving in a succinct and practical form all the information an engineman desirous of mastering the scientific principles of his daily calling would require."—*The Miller*.

"A boon to those who are striving to become efficient mechanics."—*Daily Chronicle*.

CIVIL ENGINEERING, SURVEYING, etc.

MR. HUMBER'S VALUABLE ENGINEERING BOOKS.

The Water Supply of Cities and Towns.

A COMPREHENSIVE TREATISE on the WATER-SUPPLY OF CITIES AND TOWNS. By WILLIAM HUMBER, A-M.Inst.C.E., and M. Inst. M.E., Author of "Cast and Wrought Iron Bridge Construction," &c. &c. Illustrated with 50 Double Plates, 1 Single Plate, Coloured Frontispiece, and upwards of 250 Woodcuts, and containing 400 pages of Text. Imp. 4to, £6 6s. elegantly and substantially half-bound in morocco.

List of Contents.

I. Historical Sketch of some of the means that have been adopted for the Supply of Water to Cities and Towns.—II. Water and the Foreign Matter usually associated with it.—III. Rainfall and Evaporation.—IV. Springs and the water-bearing formations of various districts.—V. Measurement and Estimation of the flow of Water.—VI. On the Selection of the Source of Supply.—VII. Wells.—VIII. Reservoirs.—IX. The Purification of Water.—X. Pumps.—XI. Pumping Machinery.—XII.

Conduits.—XIII. Distribution of Water.—XIV. Meters, Service Pipes, and House Fittings.—XV. The Law and Economy of Water Works.—XVI. Constant and Intermittent Supply.—XVII. Description of Plates.—Appendices, giving Tables of Rates of Supply, Velocities, &c. &c., together with Specifications of several Works illustrated, among which will be found: Aberdeen, Bideford, Canterbury, Dundee, Halifax, Lambeth, Rotherham, Dublin, and others.

"The most systematic and valuable work upon water supply hitherto produced in English, or in any other language. . . . Mr. Humber's work is characterised almost throughout by an exhaustiveness much more distinctive of French and German than of English technical treatises."—*Engineer*.

"We can congratulate Mr. Humber on having been able to give so large an amount of information on a subject so important as the water supply of cities and towns. The plates, fifty in number, are mostly drawings of executed works, and alone would have commanded the attention of every engineer whose practice may lie in this branch of the profession."—*Builder*.

Cast and Wrought Iron Bridge Construction.

A COMPLETE AND PRACTICAL TREATISE ON CAST AND WROUGHT IRON BRIDGE CONSTRUCTION, including Iron Foundations. In Three Parts—Theoretical, Practical, and Descriptive. By WILLIAM HUMBER, A-M.Inst.C.E., and M.Inst.M.E. Third Edition, Revised and much improved, with 115 Double Plates (20 of which now first appear in this edition), and numerous Additions to the Text. In Two Vols., imp. 4to, £6 16s. 6d. half-bound in morocco.

"A very valuable contribution to the standard literature of civil engineering. In addition to elevations, plans and sections, large scale details are given which very much enhance the instructive worth of those illustrations."—*Civil Engineer and Architect's Journal*.

"Mr. Humber states volumes, lately issued—in which the most important bridges erected during the last five years, under the direction of the late Mr. Brunel, Sir W. Cubitt, Mr. Hawkshaw, Mr. Page, Mr. Fowler, Mr. Hemans, and others among our most eminent engineers, are drawn and specified in great detail."—*Engineer*.

Strains, Calculation of.

A HANDY BOOK FOR THE CALCULATION OF STRAINS IN GIRDERS AND SIMILAR STRUCTURES, AND THEIR STRENGTH. Consisting of Formulæ and Corresponding Diagrams, with numerous details for Practical Application, &c. By WILLIAM HUMBER, A-M.Inst.C.E., &c. Fifth Edition. Crown 8vo, nearly 100 Woodcuts and 3 Plates, 7s. 6d. cloth.

"The formulæ are neatly expressed, and the diagrams good."—*Athenæum*.

"We heartily commend this really handy book to our engineer and architect readers."—*English Mechanic*.

Barlow's Strength of Materials, enlarged by Humber.

A TREATISE ON THE STRENGTH OF MATERIALS; with Rules for Application in Architecture, the Construction of Suspension Bridges, Railways, &c. By PETER BARLOW, F.R.S. A New Edition, revised by his Sons, P. W. BARLOW, F.R.S., and W. H. BARLOW, F.R.S.; to which are added, Experiments by HODGKINSON, FAIRBAIRN, and KIRKALDY; and Formulæ for Calculating Girders, &c. Arranged and Edited by WM. HUMBER, A-M.Inst.C.E. Demy 8vo, 400 pp., with 19 large Plates and numerous Woodcuts, 18s. cloth.

"Valuable alike to the student, tyro, and the experienced practitioner, it will always rank in future, as it has hitherto done, as the standard treatise on that particular subject."—*Engineer*.

"There is no greater authority than Barlow."—*Building News*.

"As a scientific work of the first class, it deserves a foremost place on the bookshelves of every civil engineer and practical mechanic."—*English Mechanic*.

MR. HUMBER'S GREAT WORK ON MODERN ENGINEERING.

Complete in Four Volumes, imperial 4to, price £12 12s., half-morocco. Each Volume sold separately as follows:—

A RECORD OF THE PROGRESS OF MODERN ENGINEERING. FIRST SERIES. Comprising Civil, Mechanical, Marine, Hydraulic, Railway, Bridge, and other Engineering Works, &c. By WILLIAM HUMBER, A-M.Inst.C.E., &c. Imp. 4to, with 36 Double Plates, drawn to a large scale, Photographic Portrait of John Hawkshaw, C.E., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Victoria Station and Roof, L. B. & S. C. R. (8 plates); Southport Pier (2 plates); Victoria Station and Roof, L. C. & D. and G. W. R. (6 plates); Roof of Cremorne Music Hall; Bridge over G. N. Railway; Roof of Station, Dutch Rhenish Rail (2 plates); Bridge over the

Thames, West London Extension Railway (5 plates); Armour Plates: Suspension Bridge, Thames (4 plates); The Allen Engine; Suspension Bridge, Avon (3 plates); Underground Railway (3 plates).

"Handsomely lithographed and printed. It will find favour with many who desire to preserve in a permanent form copies of the plans and specifications prepared for the guidance of the contractors for many important engineering works."—*Engineer*.

HUMBER'S PROGRESS OF MODERN ENGINEERING.

SECOND SERIES. Imp. 4to, with 36 Double Plates, Photographic Portrait of Robert Stephenson, C.E., M.P., F.R.S., &c., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Birkenhead Docks, Low Water Basin (15 plates); Charing Cross Station Roof, C. C. Railway (3 plates); Digswell Viaduct, Great Northern Railway; Robbery Wood Viaduct, Great Northern Railway; Iron Permanent Way; Clydach Viaduct, Merthyr, Tredegar,

and Abergavenny Railway; Ebbw Viaduct, Merthyr, Tredegar, and Abergavenny Railway; College Wood Viaduct, Cornwall Railway; Dublin Winter Palace Roof (3 plates); Bridge over the Thames, L. C. & D. Railway (6 plates); Albert Harbour, Greenock (4 plates).

"Mr. Humber has done the profession good and true service, by the fine collection of examples he has here brought before the profession and the public."—*Practical Mechanic's Journal*.

HUMBER'S PROGRESS OF MODERN ENGINEERING.

THIRD SERIES. Imp. 4to, with 40 Double Plates, Photographic Portrait of J. R. McClean, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

MAIN DRAINAGE, METROPOLIS.—North Side.—Map showing Interception of Sewers; Middle Level Sewer (2 plates); Outfall Sewer, Bridge over River Lea (3 plates); Outfall Sewer, Bridge over Marsh Lane, North Woolwich Railway, and Bow and Barking Railway Junction; Outfall Sewer, Bridge over Bow and Barking Railway (3 plates); Outfall Sewer, Bridge over East London Waterworks Feeder (2 plates); Outfall Sewer, Reservoir (2 plates); Outfall Sewer, Tumbling Bay and Outlet; Outfall Sewer, Penstocks. *South Side.*—Outfall Sewer, Bermondsey Branch (2 plates); Outfall

Sewer, Reservoir and Outlet (4 plates); Outfall Sewer, Filth Hoist; Sections of Sewers (North and South Sides).

THAMES EMBANKMENT.—Section of River Wall; Steamboat Pier, Westminster (2 plates); Landing Stairs between Charing Cross and Waterloo Bridges; York Gate (2 plates); Overflow and Outlet at Savoy Street Sewer (3 plates); Steamboat Pier, Waterloo Bridge (3 plates); Junction of Sewers, Plans and Sections; Gullies, Plans and Sections; Rolling Stock; Granite and Iron Forts.

"The drawings have a constantly increasing value, and whoever desires to possess clear representations of the two great works carried out by our Metropolitan Board will obtain Mr. Humber's volume."—*Engineer*.

HUMBER'S PROGRESS OF MODERN ENGINEERING.

FOURTH SERIES. Imp. 4to, with 36 Double Plates, Photographic Portrait of John Fowler, late Pres. Inst. C.E., and copious descriptive Letterpress, Specifications, &c., £3 3s. half-morocco.

List of the Plates and Diagrams.

Abbey Mills Pumping Station, Main Drainage, Metropolis (4 plates); Barrow Docks (5 plates); Manque Viaduct, Santiago and Valparaiso Railway (2 plates); Adam's Locomotive, St. Helen's Canal Railway (2 plates); Cannon Street Station Roof, Charing Cross Railway (3 plates); Road Bridge over the River Moka (2 plates); Telegraphic Apparatus for

Mesopotamia; Viaduct over the River Wye, Midland Railway (3 plates); St. Germans Viaduct, Cornwall Railway (2 plates); Wrought-Iron Cylinder for Diving Bell; Millwall Docks (6 plates); Milroy's Patent Excavator; Metropolitan District Railway (6 plates); Harbours, Ports, and Breakwaters (3 plates).

"We gladly welcome another year's issue of this valuable publication from the able pen of Mr. Humber. The accuracy and general excellence of this work are well known, while its usefulness in giving the measurements and details of some of the latest examples of engineering, as carried out by the most eminent men in the profession, cannot be too highly prized."—*Artisan*.

Statics, Graphic and Analytic.

GRAPHIC AND ANALYTIC STATICS, in their Practical Application to the Treatment of Stresses in Roofs, Solid Girders, Lattice, Bowstring and Suspension Bridges, Braced Iron Arches and Piers, and other Frameworks. By R. HUDSON GRAHAM, C.E. Containing Diagrams and Plates to Scale. With numerous Examples, many taken from existing Structures. Specially arranged for Class-work in Colleges and Universities. Second Edition, Revised and Enlarged. 8vo, 16s. cloth.

"Mr. Graham's book will find a place wherever graphic and analytic statics are used or studied."
—*Engineer*.

"The work is excellent from a practical point of view, and has evidently been prepared with much care. The directions for working are ample, and are illustrated by an abundance of well-selected examples. It is an excellent text-book for the practical draughtsman."
—*Athenæum*.

Practical Mathematics.

MATHEMATICS FOR PRACTICAL MEN: Being a Common-place Book of Pure and Mixed Mathematics. Designed chiefly for the use of Civil Engineers, Architects and Surveyors. By OLINTHUS GREGORY, LL.D., F.R.A.S., Enlarged by HENRY LAW, C.E. 4th Edition, carefully Revised by J. R. YOUNG, formerly Professor of Mathematics, Belfast College. With 13 Plates. 8vo, £1 1s. cloth.

"The engineer or architect will here find ready to his hand rules for solving nearly every mathematical difficulty that may arise in his practice. The rules are in all cases explained by means of examples, in which every step of the process is clearly worked out."
—*Builder*.

"One of the most serviceable books for practical mechanics. . . It is an instructive book for the student, and a text-book for him who, having once mastered the subjects it treats of, needs occasionally to refresh his memory upon them."
—*Building News*.

Hydraulic Tables.

HYDRAULIC TABLES, CO-EFFICIENTS, and FORMULÆ for finding the Discharge of Water from Orifices, Notches, Weirs, Pipes, and Rivers. With New Formulæ, Tables, and General Information on Rainfall, Catchment-Basins, Drainage, Sewerage, Water Supply for Towns and Mill Power. By JOHN NEVILLE, Civil Engineer, M.R.I.A. Third Ed., carefully Revised, with considerable Additions. Numerous Illustrs. Cr. 8vo, 14s. cloth.

"Alike valuable to students and engineers in practice; its study will prevent the annoyance of avoidable failures, and assist them to select the readiest means of successfully carrying out any given work connected with hydraulic engineering."
—*Mining Journal*.

"It is, of all English books on the subject, the one nearest to completeness. . . . From the good arrangement of the matter, the clear explanations, and a bundance of formulæ, the carefully calculated tables, and, above all, the thorough acquaintance with both theory and construction, which is displayed from first to last, the book will be found to be an acquisition."
—*Architect*.

Hydraulics.

HYDRAULIC MANUAL. Consisting of Working Tables and Explanatory Text. Intended as a Guide in Hydraulic Calculations and Field Operations. By LEWIS D'A. JACKSON, Author of "Aid to Survey Practice," "Modern Metrology," &c. Fourth Edition, Enlarged. Large cr. 8vo, 16s. cl.

"The author has had a wide experience in hydraulic engineering and has been a careful observer of the facts which have come under his notice, and from the great mass of material at his command he has constructed a manual which may be accepted as a trustworthy guide to this branch of the engineer's profession. We can heartily recommend this volume to all who desire to be acquainted with the latest development of this important subject."
—*Engineering*.

"The standard-work in this department of mechanics."
—*Scotsman*.

"The most useful feature of this work is its freedom from what is superannuated, and its thorough adoption of recent experiments; the text is, in fact, in great part a short account of the great modern experiments."
—*Nature*.

Drainage.

ON THE DRAINAGE OF LANDS, TOWNS, AND BUILDINGS. By G. D. DEMPSEY, C.E., Author of "The Practical Railway Engineer," &c. Revised, with large Additions on RECENT PRACTICE IN DRAINAGE ENGINEERING, by D. KINNEAR CLARK, M.Inst.C.E. Author of "Tramways: Their Construction and Working," "A Manual of Rules, Tables, and Data for Mechanical Engineers," &c. Second Edition, Corrected. Fcap. 8vo, 3s. cloth.

"The new matter added to Mr. Dempsey's excellent work is characterised by the comprehensive grasp and accuracy of detail for which the name of Mr. D. K. Clark is a sufficient voucher."
—*Athenæum*.

"As a work on recent practice in drainage engineering, the book is to be commended to all who are making that branch of engineering science their special study."
—*Iron*.

"A comprehensive manual on drainage engineering, and a useful introduction to the student."
—*Building News*.

Water Storage, Conveyance, and Utilisation.

WATER ENGINEERING : A Practical Treatise on the Measurement, Storage, Conveyance, and Utilisation of Water for the Supply of Towns, for Mill Power, and for other Purposes. By CHARLES SLAGG, Water and Drainage Engineer, A.M.Inst.C.E., Author of "Sanitary Work in the Smaller Towns, and in Villages," &c. With numerous Illusts. Cr. 8vo, 7s. 6d. cloth.

"As a small practical treatise on the water supply of towns, and on some applications of water-power, the work is in many respects excellent."—*Engineering*.

"The author has collated the results deduced from the experiments of the most eminent authorities, and has presented them in a compact and practical form, accompanied by very clear and detailed explanations. The application of water as a motive power is treated very carefully and exhaustively."—*Builder*.

"For anyone who desires to begin the study of hydraulics with a consideration of the practical applications of the science there is no better guide."—*Architect*.

River Engineering.

RIVER BARS: *The Causes of their Formation, and their Treatment by "Induced Tidal Scour,"* with a Description of the Successful Reduction by this Method of the Bar at Dublin. By I. J. MANN, Assist. Eng. to the Dublin Port and Docks Board. Royal 8vo, 7s. 6d. cloth.

"We recommend all interested in harbour works—and, indeed, those concerned in the improvements of rivers generally—to read Mr. Mann's interesting work on the treatment of river bars."—*Engineer*.

Trusses.

TRUSSES OF WOOD AND IRON. *Practical Applications of Science in Determining the Stresses, Breaking Weights, Safe Loads, Scantlings, and Details of Construction,* with Complete Working Drawings. By WILLIAM GRIFFITHS, Surveyor, Assistant Master, Tranmere School of Science and Art. Oblong 8vo, 4s. 6d. cloth.

"This handy little book enters so minutely into every detail connected with the construction of roof trusses, that no student need be ignorant of these matters."—*Practical Engineer*.

Railway Working.

SAFE RAILWAY WORKING. *A Treatise on Railway Accidents: Their Cause and Prevention; with a Description of Modern Appliances and Systems.* By CLEMENT E. STRETTON, C.E., Vice-President and Consulting Engineer, Amalgamated Society of Railway Servants. With Illustrations and Coloured Plates. Third Edition, Enlarged. Crown 8vo, 3s. 6d. cloth.

"A book for the engineer, the directors, the managers; and, in short, all who wish for information on railway matters will find a perfect encyclopædia in 'Safe Railway Working.'"—*Railway Review*.

"We commend the remarks on railway signalling to all railway managers, especially where a uniform code and practice is advocated."—*Herepath's Railway Journal*.

"The author may be congratulated on having collected, in a very convenient form, much valuable information on the principal questions affecting the safe working of railways."—*Railway Engineer*.

Oblique Bridges.

A PRACTICAL AND THEORETICAL ESSAY ON OBLIQUE BRIDGES. With 13 large Plates. By the late GEORGE WATSON BUCK, M.I.C.E. Third Edition, revised by his Son, J. H. WATSON BUCK, M.I.C.E.; and with the addition of Description to Diagrams for Facilitating the Construction of Oblique Bridges, by W. H. BARLOW, M.I.C.E. Royal 8vo, 12s. cloth.

"The standard text-book for all engineers regarding skew arches is Mr. Buck's treatise, and it would be impossible to consult a better."—*Engineer*.

"Mr. Buck's treatise is recognised as a standard text-book, and his treatment has divested the subject of many of the intricacies supposed to belong to it. As a guide to the engineer and architect, on a confessedly difficult subject, Mr. Buck's work is unsurpassed."—*Building News*.

Tunnel Shafts.

THE CONSTRUCTION OF LARGE TUNNEL SHAFTS: *A Practical and Theoretical Essay.* By J. H. WATSON BUCK, M.Inst.C.E., Resident Engineer, London and North-Western Railway. Illustrated with Folding Plates. Royal 8vo, 12s. cloth.

"Many of the methods given are of extreme practical value to the mason; and the observations on the form of arch, the rules for ordering the stone, and the construction of the templates will be found of considerable use. We commend the book to the engineering profession."—*Building News*.

"Will be regarded by civil engineers as of the utmost value, and calculated to save much time and obviate many mistakes."—*Colliery Guardian*.

Student's Text-Book on Surveying.

PRACTICAL SURVEYING: A Text-Book for Students preparing for Examination or for Survey-work in the Colonies. By GEORGE W. USILL, A.M.I.C.E., Author of "The Statistics of the Water Supply of Great Britain." With Four Lithographic Plates and upwards of 330 Illustrations. Second Edition, Revised. Crown 8vo, 7s. 6d. cloth.

"The best forms of instruments are described as to their construction, uses and modes of employment, and there are innumerable hints on work and equipment such as the author, in his experience as surveyor, draughtsman, and teacher, has found necessary, and which the student in his inexperience will find most serviceable."—*Engineer*.

"The latest treatise in the English language on surveying, and we have no hesitation in saying that the student will find it a better guide than any of its predecessors. . . . Deserves to be recognised as the first book which should be put in the hands of a pupil of Civil Engineering, and every gentleman of education who sets out for the Colonies would find it well to have a copy."—*Architect*.

Survey Practice.

AID TO SURVEY PRACTICE, for Reference in Surveying, Levelling, and Setting-out; and in Route Surveys of Travellers by Land and Sea. With Tables, Illustrations, and Records. By LOWIS D'A. JACKSON, A.M.I.C.E., Author of "Hydraulic Manual," "Modern Metrology," &c. Second Edition, Enlarged. Large crown 8vo, 12s. 6d. cloth.

"Mr. Jackson has produced a valuable *vade-mecum* for the surveyor. We can recommend this book as containing an admirable supplement to the teaching of the accomplished surveyor."—*Athenæum*.

"As a text-book we should advise all surveyors to place it in their libraries, and study well the matured instructions afforded in its pages."—*Coltrey Guardian*.

"The author brings to his work a fortunate union of theory and practical experience which, aided by a clear and lucid style of writing, renders the book a very useful one."—*Builder*.

Surveying, Land and Marine.

LAND AND MARINE SURVEYING, in Reference to the Preparation of Plans for Roads and Railways; Canals, Rivers, Towns' Water Supplies; Docks and Harbours. With Description and Use of Surveying Instruments. By W. D. HASKOLL, C.E., Author of "Bridge and Viaduct Construction," &c. Second Edition, Revised, with Additions. Large cr. 8vo, 9s. 6d.

"This book must prove of great value to the student. We have no hesitation in recommending it, feeling assured that it will more than repay a careful study."—*Mechanical World*.

"A most useful and well arranged book for the aid of a student. We can strongly recommend it as a carefully-written and valuable text-book. It enjoys a well-deserved repute among surveyors."—*Builder*.

"This volume cannot fail to prove of the utmost practical utility. It may be safely recommended to all students who aspire to become clean and expert surveyors."—*Mining Journal*.

Field-Book for Engineers.

THE ENGINEER'S, MINING SURVEYOR'S, AND CONTRACTOR'S FIELD-BOOK. Consisting of a Series of Tables, with Rules, Explanations of Systems, and use of Theodolite for Traverse Surveying and Plotting the Work with minute accuracy by means of Straight Edge and Set Square only; Levelling with the Theodolite, Casting-out and Reducing Levels to Datum, and Plotting Sections in the ordinary manner; setting-out Curves with the Theodolite by Tangential Angles and Multiples, with Right and Left-hand Readings of the Instrument; Setting-out Curves without Theodolite, on the System of Tangential Angles by sets of Tangents and Off-sets; and Earthwork Tables to 80 feet deep, calculated for every 6 inches in depth. By W. DAVIS HASKOLL, C.E. With numerous Woodcuts. Fourth Edition, Enlarged. Crown 8vo, 12s. cloth.

"The book is very handy; the separate tables of sines and tangents to every minute will make it useful for many other purposes, the genuine traverse tables existing all the same."—*Athenæum*.

"Every person engaged in engineering field operations will estimate the importance of such a work and the amount of valuable time which will be saved by reference to a set of reliable tables prepared with the accuracy and fulness of those given in this volume."—*Railway News*.

Levelling.

A TREATISE ON THE PRINCIPLES AND PRACTICE OF LEVELLING. Showing its Application to purposes of Railway and Civil Engineering, in the Construction of Roads; with Mr. TELFORD'S Rules for the same. By FREDERICK W. SIMMS, F.G.S., M.Inst.C.E. Seventh Edition, with the addition of LAW'S Practical Examples for Setting-out Railway Curves, and TRAUTWINE'S Field Practice of Laying-out Circular Curves. With 7 Plates and numerous Woodcuts. 8vo, 8s. 6d. cloth. * * * TRAUTWINE on Curves may be had separate, 5s.

"The text-book on levelling in most of our engineering schools and colleges."—*Engineer*.

"The publishers have rendered a substantial service to the profession, especially to the younger members, by bringing out the present edition of Mr. Simms's useful work."—*Engineering*.

Trigonometrical Surveying.

AN OUTLINE OF THE METHOD OF CONDUCTING A TRIGONOMETRICAL SURVEY, for the Formation of Geographical and Topographical Maps and Plans, Military Reconnaissance, Levelling, &c., with Useful Problems, Formulæ, and Tables. By Lieut.-General FROME, R.E. Fourth Edition, Revised and partly Re-written by Major General Sir CHARLES WARREN, G.C.M.G., R.E. With 19 Plates and 115 Woodcuts. Royal 8vo, 16s. cloth.

"The simple fact that a fourth edition has been called for is the best testimony to its merits. No words of praise from us can strengthen the position so well and so steadily maintained by this work. Sir Charles Warren has revised the entire work, and made such additions as were necessary to bring every portion of the contents up to the present date."—*Broad Arrow*.

Field Fortification.

A TREATISE ON FIELD FORTIFICATION, THE ATTACK OF FORTRESSES, MILITARY MINING, AND RECONNOITRING. By Colonel I. S. MACAULAY, late Professor of Fortification in the R.M.A., Woolwich. Sixth Edition. Crown 8vo, with separate Atlas of 12 Plates, 12s. cloth.

Tunnelling.

PRACTICAL TUNNELLING. Explaining in detail the Setting-out of the works, Shaft-sinking and Heading-driving, Ranging the Lines and Levelling underground, Sub-Excavating, Timbering, and the Construction of the Brickwork of Tunnels, with the amount of Labour required for, and the Cost of, the various portions of the work. By FREDERICK W. SIMMS, F.G.S., M.Inst.C.E. Third Edition, Revised and Extended by D. KINNEAR CLARK, M.Inst.C.E. Imperial 8vo, with 21 Folding Plates and numerous Wood Engravings, 30s. cloth.

"The estimation in which Mr. Simms's book on tunnelling has been held for over thirty years cannot be more truly expressed than in the words of the late Prof. Rankine:—'The best source of information on the subject of tunnels is Mr. F.W. Simms's work on Practical Tunnelling.'"—*Architect*.

"It has been regarded from the first as a text-book of the subject. . . . Mr. Clark has added immensely to the value of the book."—*Engineer*.

Tramways and their Working.

TRAMWAYS: THEIR CONSTRUCTION AND WORKING. Embracing a Comprehensive History of the System; with an exhaustive Analysis of the various Modes of Traction, including Horse-Power, Steam, Compressed Air, Electric Traction, &c.; a Description of the Varieties of Rolling Stock; and ample Details of Cost and Working Expenses. New Edition, Thoroughly Revised, and including the Progress recently made in Tramway Construction, &c. &c. By D. KINNEAR CLARK, M.Inst.C.E. With numerous Illustrations. In One Volume, 8vo. [In preparation.]

"All interested in tramways must refer to it, as all railway engineers have turned to the author's work 'Railway Machinery.'"—*Engineer*.

"An exhaustive and practical work on tramways, in which the history of this kind of locomotion, and a description and cost of the various modes of laying tramways, are to be found."—*Building News*.

"The best form of rails, the best mode of construction, and the best mechanical appliances are so fairly indicated in the work under review, that any engineer about to construct a tramway will be enabled at once to obtain the practical information which will be of most service to him."—*Athenæum*.

Curves, Tables for Setting-out.

TABLES OF TANGENTIAL ANGLES AND MULTIPLES for Setting-out Curves from 5 to 200 Radius. By ALEXANDER BRAZEELEY, M.Inst.C.E. Fourth Edition. Printed on 48 Cards, and sold in a cloth box, waistcoat-pocket size, 3s. 6d.

"Each table is printed on a small card, which, being placed on the theodolite, leaves the hands free to manipulate the instrument—no small advantage as regards the rapidity of work."—*Engineer*.

"Very handy; a man may know that all his day's work must fall on two of these cards, which he puts into his own card-case, and leaves the rest behind."—*Athenæum*.

Earthwork.

EARTHWORK TABLES. Showing the Contents in Cubic Yards of Embankments, Cuttings, &c., of Heights or Depths up to an average of 80 feet. By JOSEPH BROADBENT, C.E., and FRANCIS CAMPIN, C.E. Crown 8vo, 5s. cloth.

"The way in which accuracy is attained, by a simple division of each cross section into three elements, two in which are constant and one variable, is ingenious."—*Athenæum*.

Heat, Expansion by.

EXPANSION OF STRUCTURES BY HEAT. By JOHN KEELY, C.E., late of the Indian Public Works and Victorian Railway Departments. Crown 8vo, 3s. 6d. cloth.

SUMMARY OF CONTENTS.

Section I. FORMULAS AND DATA.

Section II. METAL BARS.

Section III. SIMPLE FRAMES.

Section IV. COMPLEX FRAMES AND PLATES.

Section V. THERMAL CONDUCTIVITY.

Section VI. MECHANICAL FORCE OF HEAT.

Section VII. WORK OF EXPANSION AND CONTRACTION.

Section VIII. SUSPENSION BRIDGES.

Section IX. MASONRY STRUCTURES.

"The aim the author has set before him, viz., to show the effects of heat upon metallic and other structures, is a laudable one, for this is a branch of physics upon which the engineer or architect can find but little reliable and comprehensive data in books."—*Builder*.

"Whoever is concerned to know the effect of changes of temperature on such structures as suspension bridges and the like, could not do better than consult Mr. Kelly's valuable and handy exposition of the geometrical principles involved in these changes."—*Scientist*.

Earthwork, Measurement of.

A MANUAL ON EARTHWORK. By ALEX. J. S. GRAHAM, C.E. With numerous Diagrams. Second Edition. 18mo, 2s. 6d. cloth.

"A great amount of practical information, very admirably arranged, and available for rough estimates, as well as for the more exact calculations required in the engineer's and contractor's offices."—*Artisan*.

Strains in Ironwork.

THE STRAINS ON STRUCTURES OF IRONWORK; with Practical Remarks on Iron Construction. By F. W. SHEILDS, M.Inst.C.E. Second Edition, with 5 Plates. Royal 8vo, 5s. cloth.

The student cannot find a better little book on this subject."—*Engineer*.

Cast Iron and other Metals, Strength of.

A PRACTICAL ESSAY ON THE STRENGTH OF CAST IRON AND OTHER METALS. By THOMAS TREDDGOLD, C.E. Fifth Edition, including HODGKINSON'S Experimental Researches. 8vo, 12s. cloth.

Oblique Arches.

A PRACTICAL TREATISE ON THE CONSTRUCTION OF OBLIQUE ARCHES. By JOHN HART. Third Edition, with Plates. Imperial 8vo, 8s. cloth.

Girders, Strength of.

GRAPHIC TABLE FOR FACILITATING THE COMPUTATION OF THE WEIGHTS OF WROUGHT IRON AND STEEL GIRDERS, &c., for Parliamentary and other Estimates. By J. H. WATSON BUCK, M.Inst.C.E. On a Sheet, 2s. 6d.

MARINE ENGINEERING, SHIPBUILDING, NAVIGATION, etc.

Pocket-Book for Naval Architects and Shipbuilders.

THE NAVAL ARCHITECT'S AND SHIPBUILDER'S POCKET-BOOK of Formulae, Rules, and Tables, and MARINE ENGINEER'S AND SURVEYOR'S Handy Book of Reference. By CLEMENT MACKROW, Member of the Institution of Naval Architects, Naval Draughtsman. Fifth Edition, Revised and Enlarged to 700 pages, with upwards of 300 Illustrations. Fcap., 12s. 6d. strongly bound in leather. [Just published.]

SUMMARY OF CONTENTS.

SIGNS AND SYMBOLS, DECIMAL FRACTIONS.—TRIGONOMETRY.—PRACTICAL GEOMETRY.—MENSURATION.—CENTRES AND MOMENTS OF FIGURES.—MOMENTS OF INERTIA AND RADII OF GYRATION.—ALGEBRAICAL EXPRESSIONS FOR SIMPSON'S RULES.—MECHANICAL PRINCIPLES.—CENTRE OF GRAVITY.—LAWS OF MOTION.—DISPLACEMENT, CENTRE OF BUOYANCY.—CENTRE OF GRAVITY OF SHIP'S HULL.—STABILITY CURVES AND METACENTRES.—SEA AND SHALLOW-WATER WAVES.—ROLLING OF SHIPS.—PROPULSION AND RESISTANCE OF VESSELS.—SPEED TRIALS.—SAILING, CENTRE OF EFFORT.—DISTANCES DOWN RIVERS, COAST LINES.—STEERING AND RUDERS OF VESSELS.—LAUNCHING CALCULATIONS AND VELOCITIES.—WEIGHT OF MATERIAL AND GEAR.—GUN PARTICULARS AND WEIGHT.—STANDARD GAUGES.—RIVETED JOINTS AND RIVETING.—STRENGTH AND TESTS OF MATERIALS.—BINDING AND SHEARING STRESSES, ETC.—STRENGTH OF SHAFTING, PILLARS, WHEELS, ETC.—HYDRAULIC DATA, ETC.—CONIC SECTIONS, CATENARIAN CURVES.—MECHANICAL POWERS, WORK.—BOARD OF TRADE REGULATIONS FOR BOILERS AND ENGINES.—BOARD OF TRADE REGULATIONS FOR SHIPS.—LLOYD'S RULES

FOR BOILERS.—LLOYD'S WEIGHT OF CHAINS.—LLOYD'S SCANTLINGS FOR SHIPS.—DATA OF ENGINES AND VESSELS.—SHIPS' FITTINGS AND TESTS.—SEASONING PRESERVING TIMBER.—MEASUREMENT OF TIMBER.—ALLOYS, PAINTS, VARNISHES.—DATA FOR STOWAGE.—ADMIRALTY TRANSPORT REGULATIONS.—RULES FOR HORSE-POWER, SCREW PROPELLERS, ETC.—PERCENTAGES FOR BUTT STRAPS, ETC.—PARTICULARS OF YACHTS.—MASTING AND RIGGING VESSELS.—DISTANCES OF FOREIGN PORTS.—TONNAGE TABLES.—VOCABULARY OF FRENCH AND ENGLISH TERMS.—ENGLISH WEIGHTS AND MEASURES.—FOREIGN WEIGHTS AND MEASURES.—DECIMAL EQUIVALENTS.—FOREIGN MONEY.—DISCOUNT AND WAGE TABLES.—USEFUL NUMBERS AND READY RECKONERS.—TABLES OF CIRCULAR MEASURES.—TABLES OF AREAS OF AND CIRCUMFERENCES OF CIRCLES.—TABLES OF AREAS OF SEGMENTS OF CIRCLES.—TABLES OF SQUARES AND CUBES AND ROOTS OF NUMBERS.—TABLES OF LOGARITHMS OF NUMBERS.—TABLES OF HYPERBOLIC LOGARITHMS.—TABLES OF NATURAL SINES, TANGENTS, ETC.—TABLES OF LOGARITHMIC SINES, TANGENTS, ETC.

"In these days of advanced knowledge a work like this is of the greatest value. It contains a vast amount of information. We unhesitatingly say that it is the most valuable compilation for its specific purpose that has ever been printed. No naval architect, engineer, surveyor, or seaman, wood or iron shipbuilder, can afford to be without this work."—*Nautical Magazine*.

"Should be used by all who are engaged in the construction or designs of vessels. . . . Will be found to contain the most useful tables and formulae required by shipbuilders, carefully collected from the best authorities, and put together in a popular and simple form."—*Engineer*.

"The professional shipbuilder has now, in a convenient and accessible form, reliable data for solving many of the numerous problems that present themselves in the course of his work."—*Iron*.

Marine Engineering.

MARINE ENGINES AND STEAM VESSELS (A Treatise on).

By ROBERT MURRAY, C.E. Eighth Edition, thoroughly Revised, with considerable Additions by the Author and by GEORGE CARLISLE, C.E., Senior Surveyor to the Board of Trade at Liverpool. 12mo, 5s. cloth boards.

"Well adapted to give the young steamship engineer or marine engine and boiler maker a general introduction into his practical work."—*Mechanical World*.

"We feel sure that this thoroughly revised edition will continue to be as popular in the future as it has been in the past, as, for its size, it contains more useful information than any similar treatise."—*Industries*.

Electric Lighting of Ships.

ELECTRIC SHIP-LIGHTING.

By J. W. URQUHART, C.E. Crown 8vo, 7s. 6d. cloth. For full description, see p. 24.

Pocket-Book for Marine Engineers.

A POCKET-BOOK OF USEFUL TABLES AND FORMULÆ FOR MARINE ENGINEERS. By FRANK PROCTOR, A.I.N.A. Third Edition. Royal 32mo, leather, gilt edges, with strap, 4s.

"We recommend it to our readers as going far to supply a long-felt want."—*Naval Science*.
 "A most useful companion to all marine engineers."—*United Service Gazette*.

Introduction to Marine Engineering.

ELEMENTARY ENGINEERING: A Manual for Young Marine Engineers and Apprentices. In the Form of Questions and Answers on Metals, Alloys, Strength of Materials, Construction and Management of Marine Engines and Boilers, Geometry, &c. &c. With an Appendix of Useful Tables. By JOHN SHERREN BREWER, Government Marine Surveyor, Hongkong. Second Edition, Revised. Small crown 8vo, 2s. cloth.

"Contains much valuable information for the class for whom it is intended, especially in the chapters on the management of boilers and engines."—*Nautical Magazine*.
 "A useful introduction to the more elaborate text-books."—*Scottsman*.

"To a student who has the requisite desire and resolve to attain a thorough knowledge, Mr. Brewer offers decidedly useful help."—*Athenaeum*.

Navigation.

PRACTICAL NAVIGATION. Consisting of **THE SAILOR'S SEA-BOOK**, by JAMES GREENWOOD and W. H. ROSSER; together with the requisite Mathematical and Nautical Tables for the Working of the Problems, by HENRY LAW, C.E., and Professor J. R. YOUNG. Illustrated. 12mo, 7s. strongly half-bound.

Drawing for Marine Engineers.

LOCKIE'S MARINE ENGINEER'S DRAWING-BOOK. Adapted to the Requirements of the Board of Trade Examinations. By JOHN LOCKIE, C.E. With 22 Plates, Drawn to Scale. Royal 8vo, 3s. 6d. cloth.

[Just published.

"The student who learns from these drawings will have nothing to unlearn."—*Engineer*.
 "The examples chosen are essentially practical, and are such as should prove of service to engineers generally, while admirably fulfilling their specific purpose."—*Mechanical World*.

Sailmaking.

THE ART AND SCIENCE OF SAILMAKING. By SAMUEL B. SADLER, Practical Sailmaker, late in the employment of Messrs. Ratsey and Laphorne, of Cowes and Gosport. With Plates and other Illustrations. Small 4to, 12s. 6d. cloth.

[Just published.

SUMMARY OF CONTENTS.

CHAP. I. THE MATERIALS USED AND THEIR RELATION TO SAILS.—II. ON THE CENTRE OF EFFORT.—III. ON MEASURING.—IV. ON DRAWING.—V. ON THE NUMBER OF CLOTHS REQUIRED.

—VI. ON ALLOWANCES.—VII. CALCULATION OF GORES.—VIII. ON CUTTING OUT.—IX. ON ROPING.—X. ON DIAGONAL-CUT SAILS.—XI. CONCLUDING REMARKS.

"This work is very ably written, and is illustrated by diagrams and carefully-worked calculations. The work should be in the hands of every sailmaker, whether employer or employed, as it cannot fail to assist them in the pursuit of their important avocations."—*Isle of Wight Herald*.

"This extremely practical work gives a complete education in all the branches of the manufacture, cutting out, roping, seaming, and goring. It is copiously illustrated, and will form a first-rate text-book and guide."—*Portsmouth Times*.

"The author of this work has rendered a distinct service to all interested in the art of sail-making. The subject of which he treats is a congenial one. Mr. Sadler is a practical sailmaker, and has devoted years of careful observation and study to the subject; and the results of the experience thus gained he has set forth in the volume before us."—*Steamship*.

Chain Cables.

CHAIN CABLES AND CHAINS. Comprising Sizes and Curves of Links, Studs, &c., Iron for Cables and Chains, Chain Cable and Chain Making, Forming and Welding Links, Strength of Cables and Chains, Certificates for Cables, Marking Cables, Prices of Chain Cables and Chains, Historical Notes, Acts of Parliament, Statutory Tests, Charges for Testing, List of Manufacturers of Cables, &c. &c. By THOMAS W. TRAILL, F.E.R.N., M. Inst. C.E., Engineer Surveyor in Chief, Beard of Trade, Inspector of Chain Cable and Anchor Proving Establishments, and General Superintendent, Lloyd's Committee on Proving Establishments. With numerous Tables, Illustrations and Lithographic Drawings. Folio, £2 2s. cloth, bevelled boards.

"It contains a vast amount of valuable information. Nothing seems to be wanting to make it a complete and standard work of reference on the subject."—*Nautical Magazine*.

MINING AND METALLURGY.

Metalliferous Mining in the United Kingdom.

BRITISH MINING: A Treatise on the History, Discovery, Practical Development, and Future Prospects of Metalliferous Mines in the United Kingdom. By ROBERT HUNT, F.R.S., Keeper of Mining Records; Editor of "Ure's Dictionary of Arts, Manufactures, and Mines," &c. Upwards of 950 pp., with 230 Illustrations. Second Edition, Revised. Super-royal 8vo, £2 2s. cloth.

"One of the most valuable works of reference of modern times. Mr. Hunt, as keeper of mining records of the United Kingdom, has had opportunities for such a task not enjoyed by anyone else, and has evidently made the most of them. . . . The language and style adopted are good, and the treatment of the various subjects laborious, conscientious, and scientific."—*Engineering*.

"The book is, in fact, a treasure-house of statistical information on mining subjects, and we know of no other work embodying so great a mass of matter of this kind. Were this the only merit of Mr. Hunt's volume, it would be sufficient to render it indispensable in the library of everyone interested in the development of the mining and metallurgical industries of this country."—*Athenaeum*.

"A mass of information not elsewhere available, and of the greatest value to those who may be interested in our great mineral industries."—*Engineer*.

Metalliferous Minerals and Mining.

A TREATISE ON METALLIFEROUS MINERALS AND MINING. By D. C. DAVIES, F.G.S., Mining Engineer, &c., Author of "A Treatise on Slate and Slate Quarrying." Fifth Edition, thoroughly Revised and much Enlarged, by his Son, E. HENRY DAVIES, M.E., F.G.S. With about 150 Illustrations. Crown 8vo, 12s. 6d. cloth. [Just published.]

"Neither the practical miner nor the general reader interested in mines can have a better book for his companion and his guide."—*Mining Journal*. [Mining World.]

"We are doing our readers a service in calling their attention to this valuable work."—

"A book that will not only be useful to the geologist, the practical miner, and the metallurgist but also very interesting to the general public."—*Iron*.

"As a history of the present state of mining throughout the world this book has a real value, and it supplies an actual want."—*Athenaeum*.

Earthy Minerals and Mining.

A TREATISE ON EARTHY & OTHER MINERALS AND MINING. By D. C. DAVIES, F.G.S., Author of "Metalliferous Minerals," &c. Third Edition. Revised and Enlarged, by his Son, E. HENRY DAVIES, M.E., F.G.S. With about 100 Illusts. Cr. 8vo, 12s. 6d. cl. [Just published.]

"We do not remember to have met with any English work on mining matters that contains the same amount of information packed in equally convenient form."—*Academy*.

"We should be inclined to rank it as among the very best of the handy technical and trades manuals which have recently appeared."—*British Quarterly Review*.

Mining Machinery.

MACHINERY FOR METALLIFEROUS MINES, including Motive Power, Haulage, Transport, and Electricity as applied to Mining. By E. HENRY DAVIES, M.E., F.G.S., &c. &c. [In preparation.]

Underground Pumping Machinery.

MINE DRAINAGE. Being a Complete and Practical Treatise on Direct-Acting Underground Steam Pumping Machinery, with a Description of a large number of the best known Engines, their General Utility and the Special Sphere of their Action, the Mode of their Application, and their merits compared with other forms of Pumping Machinery. By STEPHEN MICHELL. 8vo, 15s. cloth.

"Will be highly esteemed by colliery owners and lessees, mining engineers, and students generally who require to be acquainted with the best means of securing the drainage of mines. It is a most valuable work, and stands almost alone in the literature of steam pumping machinery."—*Colliery Guardian*.

"Much valuable information is given, so that the book is thoroughly worthy of an extensive circulation amongst practical men and purchasers of machinery."—*Mining Journal*.

Mining Tools.

A MANUAL OF MINING TOOLS. For the Use of Mine Managers, Agents, Students, &c. By WILLIAM MORGANS, Lecturer on Practical Mining at the Bristol School of Mines. 12mo, 2s. 6d. cloth limp.

ATLAS OF ENGRAVINGS to Illustrate the above, containing 235 Illustrations of Mining Tools, drawn to scale. 4to, 4s. 6d. cloth.

"Students in the science of mining, and overmen, captains, managers, and viewers may gain practical knowledge and useful hints by the study of Mr. Morgans' manual."—*Colliery Guardian*.

"A valuable work, which will tend materially to improve our mining literature."—*Mining Journal*.

Prospecting for Gold and other Metals.

THE PROSPECTOR'S HANDBOOK: A Guide for the Prospector and Traveller in Search of Metal-Bearing or other Valuable Minerals. By J. W. ANDERSON, M.A. (Camb.), F.R.G.S., Author of "Fiji and New Caledonia." Fifth Edition, thoroughly Revised and Enlarged. Small crown 8vo, 3s. 6d. cloth.

"Will supply a much felt want, especially among Colonists, in whose way are so often thrown many mineralogical specimens the value of which it is difficult to determine."—*Engineer*.

"How to find commercial minerals, and how to identify them when they are found, are the leading points to which attention is directed. The author has managed to pack as much practical detail into his pages as would supply material for a book three times its size."—*Mining Journal*.

Mining Notes and Formulae.

NOTES AND FORMULÆ FOR MINING STUDENTS. By JOHN HERMAN MERIVALE, M.A., Certificated Colliery Manager, Professor of Mining in the Durham College of Science, Newcastle-upon-Tyne. Third Edition, Revised and Enlarged. Small crown 8vo, 2s. 6d. cloth.

"Invaluable to anyone who is working up for an examination on mining subjects."—*Iron and Coal Trades Review*.

"The author has done his work in an exceedingly creditable manner, and has produced a book that will be of service to students, and those who are practically engaged in mining operations."—*Engineer*.

"A vast amount of technical matter of the utmost value to mining engineers, and of considerable interest to students."—*Schoolmaster*.

Miners' and Metallurgists' Pocket-Book.

A POCKET-BOOK FOR MINERS AND METALLURGISTS. Comprising Rules, Formulae, Tables, and Notes, for Use in Field and Office Work. By F. DANVERS POWER, F.G.S., M.E. Fcap. 8vo, 9s. leather, gilt edges. Just published.

"The book seems to contain an immense amount of useful information in a small space, and no doubt will prove to be a valuable and handy book for mining engineers."—C. LE NEVE FOSTER, Esq.

"Miners and metallurgists will find in this work a useful *vade-me-cum* containing a mass of rules, formulae, tables, and various other information, the necessity for reference to which occurs in their daily duties."—*Iron*.

"A marvellous compendium which every miner who desires to do work rapidly and well should hasten to buy."—*Redruth Times*.

"Mr. Power has succeeded in producing a pocket-book which certainly deserves to become the engineer's *vade-mecum*."—*Mechanical World*.

Mineral Surveying and Valuing.

THE MINERAL SURVEYOR AND VALUER'S COMPLETE GUIDE, comprising a Treatise on Improved Mining Surveying and the Valuation of Mining Properties, with New Traverse Tables. By WM. LINTERN, Mining and Civil Engineer. Third Edition, with an Appendix on "Magnetic and Angular Surveying," with Records of the Peculiarities of Needle Disturbances. With Four Plates of Diagrams, Plans, &c. 12mo, 4s. cloth.

"Mr. Lintern's book forms a valuable and thoroughly trustworthy guide."—*Iron and Coal Trades Review*.

"This new edition must be of the highest value to colliery surveyors, proprietors, and managers."—*Colliery Guardian*.

Asbestos and its Uses.

ASBESTOS: Its Properties, Occurrence, and Uses. With some Account of the Mines of Italy and Canada. By ROBERT H. JONES. With Eight Collotype Plates and other Illustrations. Crown 8vo, 12s. 6d. cloth.

"An interesting and invaluable work."—*Colliery Guardian*.

"A valuable addition to the architect's and engineer's library."—*Building News*.

Explosives.

A HANDBOOK ON MODERN EXPLOSIVES. Being a Practical Treatise on the Manufacture and Application of Dynamite, Gun-Cotton, Nitro-Glycerine, and other Explosive Compounds. Including the Manufacture of Collodion-Cotton. By M. ESSLER, Mining Engineer and Metallurgical Chemist, Author of "The Metallurgy of Gold," "The Metallurgy of Silver," &c. With about 100 Illusts. Crown 8vo, 10s. 6d. cloth.

"Useful not only to the miner, but also to officers of both services to whom blasting and the use of explosives generally may at any time become a necessary auxiliary."—*Nature*.

"A veritable mine of information on the subject of explosives employed for military, mining, and blasting purposes."—*Army and Navy Gazette*.

"The book is clearly written. Taken as a whole, we consider it an excellent little book and one that should be found of great service to miners and others who are engaged in work requiring the use of explosives."—*Athenaeum*.

Colliery Management.

THE COLLIERY MANAGER'S HANDBOOK: A Comprehensive Treatise on the Laying-out and Working of Collieries, Designed as a Book of Reference for Colliery Managers, and for the Use of Coal-Mining Students preparing for First-class Certificates. By CALER PAMELY, Mining Engineer and Surveyor; Member of the North of England Institute of Mining and Mechanical Engineers; and Member of the South Wales Institute of Mining Engineers. With nearly 500 Plans, Diagrams, and other Illustrations. Medium 8vo, about 600 pages. Price £1 5s. strongly bound.

SUMMARY OF CONTENTS.

GEOLOGY.—SEARCH FOR COAL.—SHAFT SINKING.—FITTING UP THE SHAFT AND SURFACE ARRANGEMENTS.—STEAM BOILERS AND THEIR FITTINGS.—TIMBERING AND WALLING.—NARROW WORK AND METHODS OF WORKING.—UNDERGROUND CONVEYANCE.—DRAINAGE.—THE GASES MET WITH IN MINES; VENTILATION.—ON

THE FRICTION OF AIR IN MINES.—SURVEYING AND PLANNING.—SAFETY LAMPS AND FIRE-DAMP DETECTORS.—SUNDRY AND INCIDENTAL OPERATIONS AND APPLIANCES.—MISCELLANEOUS QUESTIONS AND ANSWERS.

Appendix: SUMMARY OF REPORT OF H.M. COMMISSIONERS ON ACCIDENTS IN MINES.

*** OPINIONS OF THE PRESS.

"Mr. Pameley has not only given us a comprehensive reference book of a very high order, suitable to the requirements of mining engineers and colliery managers, but at the same time has provided mining students with a class-book that is as interesting as it is instructive."—*Colliery Manager*.

"Mr. Pameley's work is eminently suited to the purpose for which it is intended—being clear, interesting, exhaustive, rich in detail, and up to date, giving descriptions of the very latest machines in every department. . . . A mining engineer could scarcely go wrong who followed this work."—*Colliery Guardian*.

"This is the most complete 'all round' work on coal-mining published in the English language. . . . No library of coal-mining books is complete without it."—*Colliery Engineer* (Scranton, Pa., U.S.A.).

"Mr. Pameley's work is in all respects worthy of our admiration. No person in any responsible position connected with mines should be without a copy."—*Westminster Review*.

Coal and Iron.

THE COAL AND IRON INDUSTRIES OF THE UNITED KINGDOM. Comprising a Description of the Coal Fields, and of the Principal Seams of Coal, with Returns of their Produce and its Distribution, and Analyses of Special Varieties. Also an Account of the occurrence of Iron Ores in Veins or Seams; Analyses of each Variety; and a History of the Rise and Progress of Pig Iron Manufacture. By RICHARD MEADE, Assistant Keeper of Mining Records. With Maps. 8vo, £1 8s. cloth.

"The book is one which must find a place on the shelves of all interested in coal and iron production, and in the iron, steel, and other metallurgical industries."—*Engineer*.

"Of this book we may unreservedly say that it is the best of its class which we have ever met.

A book of reference which no one engaged in the iron or coal trades should omit from his library."—*Iron and Coal Trades Review*.

Coal Mining.

COAL AND COAL MINING: A Rudimentary Treatise on. By the late Sir WARINGTON W. SMYTH, M.A., F.R.S., &c., Chief Inspector of the Mines of the Crown. Seventh Edition, Revised and Enlarged. With numerous Illustrations. 12mo, 4s. cloth boards.

"As an outline is given of every known coal-field in this and other countries, as well as of the principal methods of working, the book will doubtless interest a very large number of readers."—*Mining Journal*.

Subterraneous Surveying.

SUBTERRANEAN SURVEYING, Elementary and Practical Treatise on, with and without the Magnetic Needle. By THOMAS FENWICK, Surveyor of Mines, and THOMAS BAKER, C.E. Illust. 12mo, 3s. cloth boards.

Granite Quarrying.

GRANITES AND OUR GRANITE INDUSTRIES. By GEORGE F. HARRIS, F.G.S., Membre de la Société Belge de Géologie, Lecturer on Economic Geology at the Birkbeck Institution, &c. With Illustrations. Crown 8vo, 2s. 6d. cloth.

"A clearly and well-written manual for persons engaged or interested in the granite industry."—*Scottsman*.

"An interesting work, which will be deservedly esteemed."—*Colliery Guardian*.

"An exceedingly interesting and valuable monograph on a subject which has hitherto received unaccountably little attention in the shape of systematic literary treatment."—*Scottish Leader*.

Gold, Metallurgy of.

THE METALLURGY OF GOLD: A Practical Treatise on the Metallurgical Treatment of Gold-bearing Ores. Including the Processes of Concentration and Chlorination, and the Assaying, Melting, and Refining of Gold. By M. EISSLER, Mining Engineer and Metallurgical Chemist, formerly Assistant Assayer of the U. S. Mint, San Francisco. Third Edition, Revised and greatly Enlarged. With 187 Illustrations. Crown 8vo, 12s. 6d. cloth.

"This book thoroughly deserves its title of a 'Practical Treatise.' The whole process of gold-milling, from the breaking of the quartz to the assay of the bullion, is described in clear and orderly narrative and with much, but not too much, fulness of detail."—*Saturday Review*.

"The work is a storehouse of information and valuable data, and we strongly recommend it to all professional men engaged in the gold-mining industry."—*Mining Journal*.

Silver, Metallurgy of.

THE METALLURGY OF SILVER: A Practical Treatise on the Amalgamation, Roasting, and Lixiviation of Silver Ores. Including the Assaying, Melting and Refining, of Silver Bullion. By M. EISSLER, Author of "The Metallurgy of Gold," &c. Second Edition, Enlarged. With 150 Illustrations. Crown 8vo, 10s. 6d. cloth.

"A practical treatise, and a technical work which we are convinced will supply a long-felt want amongst practical men, and at the same time be of value to students and others indirectly connected with the industries."—*Mining Journal*.

"From first to last the book is thoroughly sound and reliable."—*Colliery Guardian*.

"For chemists, practical miners, assayers, and investors alike, we do not know of any work on the subject so handy and yet so comprehensive."—*Glasgow Herald*.

Lead, Metallurgy of.

THE METALLURGY OF ARGENTIFEROUS LEAD: A Practical Treatise on the Smelting of Silver-Lead Ores and the Refining of Lead Bullion. Including Reports on various Smelting Establishments and Descriptions of Modern Smelting Furnaces and Plants in Europe and America. By M. EISSLER, M.E., Author of "The Metallurgy of Gold," &c. Crown 8vo, 400 pp., with 183 Illustrations, 12s. 6d. cloth.

"This is a very good book."—*Colliery Guardian*.

"The numerous metallurgical processes, which are fully and extensively treated of, embrace all the stages experienced in the passage of the lead from the various natural states to its issue from the refinery as an article of commerce."—*Practical Engineer*.

"The present volume fully maintains the reputation of the author. Those who wish to obtain a thorough insight into the present state of this industry cannot do better than read this volume, and all mining engineers cannot fail to find many useful hints and suggestions in it."—*Industries*.

"It is most carefully written and illustrated with capital drawings and diagrams. In fact, it is the work of an expert for experts, by whom it will be prized as an indispensable text-book."—*Bristol Mercury*.

Iron, Metallurgy of.

METALLURGY OF IRON. Containing History of Iron Manufacture, Methods of Assay, and Analyses of Iron Ores, Processes of Manufacture of Iron and Steel, &c. By H. BAUERMAN, F.G.S. A.R.S.M. With numerous Illustrations. Sixth Edition, Revised and Enlarged. 12mo, 5s. 6d. cloth.

"Carefully written, it has the merit of brevity and conciseness, as to less important points; while all material matters are very fully and thoroughly entered into."—*Standard*.

Iron Mining.

THE IRON ORES OF GREAT BRITAIN AND IRELAND: Their Mode of Occurrence, Age, and Origin, and the Methods of Searching for and Working them, with a Notice of some of the Iron Ores of Spain. By J. D. KENDALL, F.G.S., M.E. Crown 8vo, with Illustrs., 16s. cloth.

[Nearly ready.]

SUMMARY OF CONTENTS.

THE EARLY WORKING OF IRON ORE.—THE HAEMATITE DEPOSITS OF WEST CUMBERLAND AND FURNESS.—THE IRON ORES OF CORNWALL, DEVON, AND WEST SOMERSET.—THE LIMONITE OF THE FOREST OF DEAN AND SOUTH WALES.—THE SIDERITE AND LIMONITE OF ALSTON AND WEARDALE. THE ARGILLACEOUS IRONSTONES OF THE CARBONIFEROUS ROCKS.—THE

IRON ORES OF THE SECONDARY ROCKS.—THE IRON ORES OF ANTRIM.—SOME OF THE IRON ORES OF SPAIN.—THE AGE AND ORIGIN OF IRON ORE DEPOSITS.—SEARCHING FOR AND WORKING IRON ORES.—WORKING COSTS AND SELLING PRICES.—RENTS, ROYALTIES, WAY-LEAVES, &c.—EPITOMES OF LEASES, &c. &c.

ELECTRICITY, ELECTRICAL ENGINEERING, etc.

Electrical Engineering.

THE ELECTRICAL ENGINEER'S POCKET-BOOK OF MODERN RULES, FORMULÆ, TABLES, AND DATA. By H. R. KEMPE, M.Inst.E.E., A.M.Inst.C.E., Technical Officer, Postal Telegraphs, Author of "A Handbook of Electrical Testing," &c. Second Edition, thoroughly Revised, with Additions. With numerous Illustrations. Royal 32mo, oblong, 5s. leather. [Just published.]

"There is very little in the shape of formulæ or data which the electrician is likely to want in a hurry which cannot be found in its pages."—*Practical Engineer.*

"A very useful book of reference for daily use in practical electrical engineering and its various applications to the industries of the present day."—*Iron.*

"It is the best book of its kind."—*Electrical Engineer.*

"Well arranged and compact. The 'Electrical Engineer's Pocket-Book' is a good one."—*Electrician.*

"Strongly recommended to those engaged in the various electrical industries."—*Electrical Review.*

Electric Lighting.

ELECTRIC LIGHT FITTING: A Handbook for Working Electrical Engineers, embodying Practical Notes on Installation Management. By JOHN W. URQUHART, Electrician, Author of "Electric Light," &c. With numerous Illustrations. Crown 8vo, 5s. cloth.

"This volume deals with what may be termed the mechanics of electric lighting, and is addressed to men who are already engaged in the work or are training for it. The work traverses a great deal of ground, and may be read as a sequel to the same author's useful work on 'Electric Light.'"—*Electrician.*

"This is an attempt to state in the simplest language the precautions which should be adopted in installing the electric light, and to give information, for the guidance of those who have to run the plant when installed. The book is well worth the perusal of the workmen for whom it is written."—*Electrical Review.*

"We have read this book with a good deal of pleasure. We believe that the book will be of use to practical workmen, who will not be alarmed by finding mathematical formulæ which they are unable to understand."—*Electrical Plant.*

"Eminently practical and useful. . . . Ought to be in the hands of everyone in charge of an electric light plant."—*Electrical Engineer.*

"Altogether Mr. Urquhart has succeeded in producing a really capital book, which we have no hesitation in recommending to the notice of working electricians and electrical engineers."—*Mechanical World.*

Electric Light.

ELECTRIC LIGHT: Its Production and Use. Embodying Plain Directions for the Treatment of Dynamo-Electric Machines, Batteries, Accumulators, and Electric Lamps. By J. W. URQUHART, C.E., Author of "Electric Light Fitting," "Electroplating," &c. Fifth Edition, carefully Revised, with Large Additions and 145 Illustrations. Crown 8vo, 7s. 6d. cloth. [Just published.]

"The whole ground of electric lighting is more or less covered and explained in a very clear and concise manner."—*Electrical Review.*

"Contains a good deal of very interesting information, especially in the parts where the author gives dimensions and working costs."—*Electrical Engineer.*

"A miniature *vide-mecum* of the salient facts connected with the science of electric lighting."—*Electrician.*

"You cannot for your purpose have a better book than 'Electric Light,' by Urquhart."—*Engineer.*

"The book is by far the best that we have yet met with on the subject."—*Athenæum.*

Construction of Dynamos.

DYNAMO CONSTRUCTION: A Practical Handbook for the Use of Engineer Constructors and Electricians-in-Charge. Embracing Framework Building, Field Magnet and Armature Winding and Grouping, Compounding, &c. With Examples of leading English, American, and Continental Dynamos and Motors. By J. W. URQUHART, Author of "Electric Light," "Electric Light Fitting," &c. With upwards of 100 Illustrations. Crown 8vo, 7s. 6d. cloth. [Just published.]

"Mr. Urquhart's book is the first one which deals with these matters in such a way that the engineering student can understand them. The book is very readable, and the author leads his readers up to difficult subjects by reasonably simple tests."—*Engineering Review.*

"The author deals with his subject in a style so popular as to make his volume a handbook of great practical value to engineer constructors and electricians in charge of lighting installations."—*Scotsman.*

"'Dynamo Construction' more than sustains the high character of the author's previous publications. It is sure to be widely read by the large and rapidly increasing number of practical electricians."—*Glasgow Herald.*

"A book for which a demand has long existed."—*Mechanical World*

Electric Lighting of Ships.

ELECTRIC SHIP-LIGHTING: A Handbook on the Practical Fitting and Running of Ship's Electrical Plant. For the Use of Shipowners and Builders, Marine Electricians, and Sea-going Engineers in Charge. By J. W. URQUHART, C.E., Author of "Electric Light," &c. With numerous illustrations. Crown 8vo, 7s 6d. cloth. [Just published.]

"The subject of ship electric lighting is one of vast importance in these days, and Mr Urquhart is to be highly complimented for placing such a valuable work at the service of the practical marine electrician."—*The Steamship*.

"Distinctly a book which of its kind stands almost alone, and for which there should be a demand."—*Electrical Review*.

Electric Lighting.

THE ELEMENTARY PRINCIPLES OF ELECTRIC LIGHTING.

By ALAN A. CAMPBELL SWINTON, Associate I.E.E. Second Edition, Enlarged and Revised. With 16 illustrations. Crown 8vo, 1s. 6d. cloth.

"Anyone who desires a short and thoroughly clear exposition of the elementary principles of electric-lighting cannot do better than read this little work."—*Bradford Observer*.

Dynamic Electricity.

THE ELEMENTS OF DYNAMIC ELECTRICITY AND

MAGNETISM. By PHILIP ATKINSON, A.M., Ph.D., Author of "Elements of Static Electricity," "The Elements of Electric Lighting," &c. &c. Crown 8vo, 417 pp., with 120 illustrations, 10s. 6d. cloth.

Dynamo Construction.

HOW TO MAKE A DYNAMO: A Practical Treatise for Amateurs.

Containing numerous illustrations and Detailed Instructions for Constructing a Small Dynamo, to Produce the Electric Light. By ALFRED CROFTS. Fourth Edition, Revised and Enlarged. Crown 8vo, 2s. cloth. [Just published.]

"The instructions given in this unpretentious little book are sufficiently clear and explicit to enable any amateur mechanic possessed of average skill and the usual tools to be found in an amateur's workshop, to build a practical dynamo machine."—*Electrician*.

Text Book of Electricity.

THE STUDENT'S TEXT-BOOK OF ELECTRICITY. By

HENRY M. NOAD, Ph.D., F.R.S. New Edition, carefully Revised With Introduction and Additional Chapters, by W. H. PREECE, M.I.C.E., Vice-President of Society of Telegraph Engineers, &c. With 470 illustrations. Crown 8vo, 12s. 6d. cloth.

"We can recommend Dr. Noad's book for clear style, great range of subject, a good index, and a plethora of woodcuts. Such collections as the present are indispensable."—*Athenæum*.

"An admirable text-book for every student—beginner or advanced—of electricity."—*Engineering*.

Electricity.

A MANUAL OF ELECTRICITY: Including Galvanism, Magnetism, Dia-Magnetism, Electro-Dynamics, Magneto-Electricity, and the Electric Telegraph. By HENRY M. NOAD, Ph.D., F.R.S., F.C.S. Fourth Edition.

With 500 Woodcuts. 8vo, £1 4s. cloth.

* * * This is the original work of Dr. Noad (published in 1859) upon which the STUDENT'S TEXT-BOOK (see above) may be said to be founded. Very few copies of it are left.

A New Dictionary of Electricity.

THE STANDARD ELECTRICAL DICTIONARY. A Popular Dictionary of Words and Terms Used in the Practice of Electric Engineering. By T. O'CONNOR SLOANE, A.M., Ph.D., Author of "The Arithmetic of Electricity," &c. Cr. 8vo, 630 pp., 350 Illusts., 12s. 6d. cl. [Just published.]

NOTE.—The purpose of this work is to present the public with a concise and practical book of reference. . . . Each title or subject is defined once in the text, and where a title is synonymous with one or more others the definition is given under one title, and the others appear at the foot of the article as synonyms. The work comprises upwards of 3,000 definitions, and will be found indispensable by all who are interested in electrical science and desire to keep abreast with the progress of the times.

An encyclopædia of electrical science in the compass of a dictionary. The information given is sound and clear. The book is well printed, well illustrated, and well up to date, and may be confidently recommended."—*Builder*.

ARCHITECTURE, BUILDING, etc.**Sir Wm. Chambers's Treatise on Civil Architecture.****THE DECORATIVE PART OF CIVIL ARCHITECTURE.**

By Sir WILLIAM CHAMBERS, F.R.S. With Portrait, Illustrations, Notes, and an Examination of Grecian Architecture, by JOSEPH GWILT, F.S.A. Revised and Edited by W. H. LEEDS, with a Memoir of the Author. 66 Plates, 4to, 21s. cloth.

Mechanics for Architects.

THE MECHANICS OF ARCHITECTURE: A Treatise on Applied Mechanics, especially Adapted to the Use of Architects. By E. W. TARN, M.A., Author of "The Science of Building," &c. Illustrated with 125 Diagrams. Crown 8vo, 7s. 6d. cloth. [just published.

SUMMARY OF CONTENTS.

CHAP. I. FORCES IN EQUILIBRIUM.—II. MOMENTS OF FORCES.—III. CENTRE OF GRAVITY.—IV. RESISTANCE OF MATERIALS TO STRESS.—V. DEFLECTION OF BEAMS.—VI. STRENGTH OF PILARS.—VII. ROOFS, TRUSSES.—VIII.

ARCHES.—IX. DOMES, SPIRES.—X. BUTTRESSES, SHORING, RETAINING WALLS, FOUNDATIONS.—XI. EFFECT OF WIND ON BUILDINGS.—XII. MISCELLANEOUS EXAMPLES AND SOLUTIONS.

Villa Architecture.

A HANDY BOOK OF VILLA ARCHITECTURE: Being a Series of Designs for Villa Residences in various Styles. With Outline Specifications and Estimates. By C. WICKES, Architect, Author of "The Spires and Towers of England," &c. 61 Plates, 4to, £1 11s. 6d. half-morocco, gilt edges.

"The whole of the designs bear evidence of their being the work of an artistic architect, and they will prove very valuable and suggestive."—*Building News*.

Text-Book for Architects.

THE ARCHITECT'S GUIDE: Being a Text-Book of Useful Information for Architects, Engineers, Surveyors, Contractors, Clerks of Works, &c. &c. By FREDERICK ROGERS, Architect, Author of "Specifications for Practical Architecture," &c. Second Edition, Revised and Enlarged. With numerous Illustrations. Crown 8vo, 6s. cloth.

"As a text-book of useful information for architects, engineers, surveyors, &c., it would be hard to find a handier or more complete little volume."—*Standard*.

Taylor and Cresy's Rome.

THE ARCHITECTURAL ANTIQUITIES OF ROME. By the late G. L. TAYLOR, Esq., F.R.I.B.A., and EDWARD CRESY, Esq. New Edition, thoroughly Revised by the Rev. ALEXANDER TAYLOR, M.A. (son of the late G. L. Taylor, Esq.), Fellow of Queen's College, Oxford, and Chaplain of Gray's Inn. Large folio, with 130 Plates, £3 3s. half-bound.

"Taylor and Cresy's work has from its first publication been ranked among those professional books which cannot be bettered. . . . It would be difficult to find examples of drawings, even among those of the most painstaking students of Gothic, more thoroughly worked out than are the one hundred and thirty plates in this volume."—*Architect*.

Linear Perspective.

ARCHITECTURAL PERSPECTIVE: The whole Course and Operations of the Draughtsman in Drawing a Large House in Linear Perspective. Illustrated by 39 Folding Plates. By F. O. FERGUSON. Demy 8vo, 3s. 6d. boards. [just published.

"In a series of graphic illustrations of the actual processes the author shows the practical part of the art. It is all so easy and so clear that a child could follow him, and generations of students yet unborn will bless the name of Ferguson. . . . It is the most intelligible of the treatises on this ill treated subject that I have met with."—E. INGRESS BELL, Esq., in the *R.I.B.A. Journal*.

Architectural Drawing.

PRACTICAL RULES ON DRAWING, for the Operative Builder and Young Student in Architecture. By GEORGE PYNE. With 14 Plates, 4to, 7s. 6d. boards.

Vitruvius' Architecture.

THE ARCHITECTURE OF MARCUS VITRUVIUS POLLIO. Translated by JOSEPH GWILT, F.S.A., F.R.A.S. New Edition, Revised by he Translator. With 23 Plates. Fcap. 8vo, 3s. cloth.

The New Builder's Price Book, 1893.

LOCKWOOD'S BUILDER'S PRICE BOOK FOR 1893. A Comprehensive Handbook of the Latest Prices and Data for Builders, Architects, Engineers, and Contractors. *Re-constructed, Re-written, and Greatly Enlarged.* By FRANCIS T. W. MILLER. 640 closely-printed pages, crown 8vo, 4s. cloth.

* * * OPINIONS OF THE PRESS.

"This book is a very useful one, and should find a place in every English office connected with the building and engineering professions."—*Industries.*

"This Price Book has been set up in new type. . . . Advantage has been taken of the transformation to add much additional information, and the volume is now an excellent book of reference."—*Architect.*

"In its new and revised form this Price Book is what a work of this kind should be—comprehensive, reliable, well arranged, legible, and well bound."—*British Architect.*

"A work of established reputation."—*Athenaeum.*

Designing, Measuring, and Valuing.

THE STUDENT'S GUIDE to the PRACTICE of MEASURING AND VALUING ARTIFICERS' WORK. Containing Directions for taking Dimensions, Abstracting the same, and bringing the Quantities into Bill, with Tables of Constants for Valuation of Labour, and for the Calculation of Areas and Solidities. Originally edited by EDWARD DOBSON, Architect. With Additions on Mensuration and Construction, and a New Chapter on Dilapidations, Repairs, and Contracts, by E. WYNDHAM TARN, M.A. Sixth Edition, including a Complete Form of a Bill of Quantities. With 8 Plates and 63 Woodcuts. Crown 8vo, 7s. 6d. cloth.

"Well fulfils the promise of its title-page, and we can thoroughly recommend it to the class for whose use it has been compiled. Mr. Tarn's additions and revisions have much increased the usefulness of the work, and have especially augmented its value to students."—*Engineering.*

"This edition will be found the most complete treatise on the principles of measuring and valuing artificers' work that has yet been published."—*Building News.*

Pocket Estimator and Technical Guide.

THE POCKET TECHNICAL GUIDE, MEASURER, AND ESTIMATOR FOR BUILDERS AND SURVEYORS. Containing Technical Directions for Measuring Work in all the Building Trades, Complete Specifications for Houses, Roads, and Drains, and an easy Method of Estimating the parts of a Building collectively. By A. C. BEATON, Author of "Quantities and Measurements." Sixth Edition. With 531 Woodcuts. Waistcoat-pocket size, 1s. 6d. gilt edges.

"No builder, architect, surveyor, or valuer should be without his 'Beaton.'"—*Building News.*

"Contains an extraordinary amount of information in daily requisition in measuring and estimating. Its presence in the pocket will save valuable time and trouble."—*Building World.*

Donaldson on Specifications.

THE HANDBOOK OF SPECIFICATIONS; or, Practical Guide to the Architect, Engineer, Surveyor, and Builder, in drawing up Specifications and Contracts for Works and Constructions. Illustrated by Precedents of Buildings actually executed by eminent Architects and Engineers. By Professor T. L. DONALDSON, P.R.I.B.A., &c. New Edition. In One large Vol., 8vo, with upwards of 1,000 pages of Text, and 33 Plates, £1 11s. 6d. cloth.

"In this work forty-four specifications of executed works are given, including the specifications for parts of the new Houses of Parliament, by Sir Charles Barry, and for the new Royal Exchange, by Mr. Tite, M.P. The latter, in particular, is a very complete and remarkable document. It embodies, to a great extent, as Mr. Donaldson mentions, 'the bill of quantities with the description of the works.' . . . It is valuable as a record, and more valuable still as a book of precedents. . . . Suffice it to say that Donaldson's 'Handbook of Specifications' must be bought by all architects."—*Builder.*

Bartholomew and Rogers' Specifications.

SPECIFICATIONS FOR PRACTICAL ARCHITECTURE.

A Guide to the Architect, Engineer, Surveyor, and Builder. With an Essay on the Structure and Science of Modern Buildings. Upon the Basis of the Work by ALFRED BARTHOLOMEW, thoroughly Revised, Corrected, and greatly added to by FREDERICK ROGERS, Architect. Third Edition, Revised, with Additions. With numerous Illustrations. Medium 8vo, 15s. cloth.

"The collection of specifications prepared by Mr. Rogers on the basis of Bartholomew's work is too well known to need any recommendation from us. It is one of the books with which every young architect must be equipped; for time has shown that the specifications cannot be set aside through any defect in them."—*Architect.*

Construction.

THE SCIENCE OF BUILDING: An Elementary Treatise on the Principles of Construction. By E. WYNDHAM TARN, M.A., Architect. Third Edition, Revised and Enlarged. With 59 Engravings. Fcap. 8vo, 4s. cl.

"A very valuable book, which we strongly recommend to all students."—*Builder*.

"No architectural student should be without this handbook of constructional knowledge."—*Architect*.

House Building and Repairing.

THE HOUSE-OWNER'S ESTIMATOR; or, What will it Cost to Build, Alter, or Repair? A Price Book adapted to the Use of Unprofessional People, as well as for the Architectural Surveyor and Builder. By JAMES D. SIMON, A.R.I.B.A. Edited and Revised by FRANCIS T. W. MILLER, A.R.I.B.A. With numerous Illustrations. Fourth Edition, Revised. Crown 8vo, 3s. 6d. cloth.

"In two years it will repay its cost a hundred times over."—*Field*.

"A very handy book."—*English Mechanic*.

Cottages and Villas.

COUNTRY AND SUBURBAN COTTAGES AND VILLAS: How to Plan and Build Them. Containing 33 Plates, with Introduction, General Explanations, and Description of each Plate. By JAMES W. BOGUE, Architect, Author of "Domestic Architecture," &c. 4to, 10s. 6d. cloth.

Building; Civil and Ecclesiastical.

A BOOK ON BUILDING, Civil and Ecclesiastical, including Church Restoration; with the Theory of Domes and the Great Pyramid, &c. By SIR EDMUND BECKETT, Bart., LL.D., F.R.A.S., Author of "Clocks and Watches, and Bells," &c. Second Edition, Enlarged. Fcap. 8vo, 5s. cloth.

"A book which is always amusing and nearly always instructive. The style throughout is in the highest degree condensed and epigrammatic."—*Times*.

Ventilation of Buildings.

VENTILATION. A Text Book to the Practice of the Art of Ventilating Buildings. With a Chapter upon Air Testing. By W. P. BUCHAN, R.P., Sanitary and Ventilating Engineer, Author of "Plumbing," &c. With 170 Illustrations. 12mo, 4s. cloth boards.

"Contains a great amount of useful practical information, as thoroughly interesting as it is technically reliable, and 'Ventilation' forms a worthy companion volume to the author's excellent treatise on 'Plumbing'."—*British Architect*.

"It is invaluable alike for the architect and builder, and should be in the hands of everyone who has to deal in any way with the subject of ventilation."—*Metropolitan*.

The Art of Plumbing.

PLUMBING. A Text Book to the Practice of the Art or Craft of the Plumber, with Supplementary Chapters on House Drainage, embodying the latest Improvements. By WILLIAM PATON BUCHAN, R.P., Sanitary Engineer and Practical Plumber. Sixth Edition, Enlarged to 370 pages, and 380 Illustrations. 12mo, 4s. cloth boards.

"A text-book which may be safely put in the hands of every young plumber, and which will also be found useful by architects and medical professors."—*Builder*.

"A valuable text-book, and the only treatise which can be regarded as a really reliable manual of the plumber's art."—*Building News*.

Geometry for the Architect, Engineer, etc.

PRACTICAL GEOMETRY, for the Architect, Engineer, and Mechanic. Giving Rules for the Delineation and Application of various Geometrical Lines, Figures and Curves. By E. W. TARN, M.A., Architect, Author of "The Science of Building," &c. Second Edition. With 172 Illustrations. Demy 8vo, 9s. cloth.

"No book with the same objects in view has ever been published in which the clearness of the rules laid down and the illustrative diagrams have been so satisfactory."—*Scotsman*.

The Science of Geometry.

THE GEOMETRY OF COMPASSES; or, Problems Resolved by the mere Description of Circles, and the use of Coloured Diagrams and Symbols. By OLIVER BYRNE. Coloured Plates. Crown 8vo, 3s. 6d. cloth.

"The treatise is a good one, and remarkable—like all Mr. Byrne's contributions to the science of geometry—for the lucid character of its teaching."—*Building News*.

CARPENTRY, TIMBER, etc.

Tredgold's Carpentry, Revised & Enlarged by Tarn. **THE ELEMENTARY PRINCIPLES OF CARPENTRY.**

A Treatise on the Pressure and Equilibrium of Timber Framing, the Resistance of Timber, and the Construction of Floors, Arches, Bridges, Roofs, Uniting Iron and Stone with Timber, &c. To which is added an Essay on the Nature and Properties of Timber, &c., with Descriptions of the kinds of Wood used in Building; also numerous Tables of the Scantlings of Timber for different purposes, the Specific Gravities of Materials, &c. By THOMAS TREDGOLD, C.E. With an Appendix of Specimens of Various Roofs of Iron and Stone, Illustrated. Seventh Edition, thoroughly revised and considerably enlarged by E. WYNDHAM TARN, M.A., Author of "The Science of Building," &c. With 61 Plates, Portrait of the Author, and several Woodcuts. In One large Vol., 4to, price £1 5s. cloth.

"Ought to be in every architect's and every builder's library."—*Builder*.

"A work whose monumental excellence must commend it wherever skilful carpentry is concerned. The author's principles are rather confirmed than impaired by time. The additional plates are of great intrinsic value."—*Building News*.

Woodworking Machinery.

WOODWORKING MACHINERY: Its Rise, Progress, and Construction. With Hints on the Management of Saw Mills and the Economical Conversion of Timber. Illustrated with Examples of Recent Designs by leading English, French, and American Engineers. By M. POWIS BALE, A.M.Inst.C.E., M.I.M.E. Large crown 8vo, 12s. 6d. cloth.

"Mr. Bale is evidently an expert on the subject and he has collected so much information that his book is all-sufficient for builders and others engaged in the conversion of timber."—*Architect*.

"The most comprehensive compendium of wood-working machinery we have seen. The author is a thorough master of his subject."—*Building News*.

"It should be in the office of every wood-working factory."—*English Mechanic*.

Saw Mills.

SAW MILLS: Their Arrangement and Management, and the Economical Conversion of Timber. (A Companion Volume to "Woodworking Machinery.") By M. POWIS BALE. With numerous Illustrations. Crown 8vo, 10s. 6d. cloth.

"The administration of a large sawing establishment is discussed, and the subject examined from a financial standpoint. Hence the size, shape, order, and disposition of saw-mills and the like are gone into in detail, and the course of the timber is traced from its reception to its delivery in its converted state. We could not desire a more complete or practical treatise."—*Builder*.

"We highly recommend Mr. Bale's work to the attention and perusal of all those who are engaged in the art of wood conversion, or who are about building or remodelling saw-mills on improved principles."—*Building News*.

Nicholson's Carpentry.

THE CARPENTER'S NEW GUIDE; or, Book of Lines for Carpenters; comprising all the Elementary Principles essential for acquiring knowledge of Carpentry. Founded on the late PETER NICHOLSON'S Standard Work. A New Edition, Revised by ARTHUR ASHPITEL, F.S.A. Together with Practical Rules on Drawing, by GEORGE PYNE. With 74 Plates, 4to, £1 1s. cloth.

Handrailing and Stairbuilding.

A PRACTICAL TREATISE ON HANDRAILING: Showing New and Simple Methods for Finding the Pitch of the Plank, Drawing the Moulds, Bevelling, Jointing-up, and Squaring the Wreath. By GEORGE COLLINGS. Second Edition, Revised and Enlarged, to which is added A TREATISE ON STAIRBUILDING. With Plates and Diagrams. 12mo, 2s. 6d. cloth limp.

"Will be found of practical utility in the execution of this difficult branch of joinery."—*Builder*.

"Almost every difficult phase of this somewhat intricate branch of joinery is elucidated by the aid of plates and explanatory letterpress."—*Furniture Gazette*.

Circular Work.

CIRCULAR WORK IN CARPENTRY AND JOINERY: A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS, Author of "A Practical Treatise on Handrailing." Illustrated with numerous Diagrams. Second Edition. 12mo, 2s. 6d. cloth limp.

"An excellent example of what a book of this kind should be. Cheap in price, clear in definition and practical in the examples selected."—*Builder*.

Timber Merchant's Companion.

THE TIMBER MERCHANT'S AND BUILDER'S COMPANION. Containing New and Copious Tables of the Reduced Weight and Measurement of Deals and Battens, of all sizes, from One to a Thousand Pieces, and the relative Price that each size bears per Lineal Foot to any given Price per Petersburg Standard Hundred; the Price per Cube Foot of Square Timber to any given Price per Load of 50 Feet; the proportionate Value of Deals and Battens by the Standard, to Square Timber by the Load of 50 Feet; the readiest mode of ascertaining the Price of Scantling per Lineal Foot of any size, to any given Figure per Cube Foot, &c. &c. By WILLIAM DOWSING. Fourth Edition, Revised and Corrected. Cr. 8vo, 3s. cl.

"Everything is as concise and clear as it can possibly be made. There can be no doubt that every timber merchant and builder ought to possess it."—*Hull Advertiser*.

"We are glad to see a fourth edition of these admirable tables, which for correctness and simplicity of arrangement leave nothing to be desired."—*Timber Trades Journal*.

Practical Timber Merchant.

THE PRACTICAL TIMBER MERCHANT. Being a Guide for the use of Building Contractors, Surveyors, Builders, &c., comprising useful Tables for all purposes connected with the Timber Trade, Marks of Wood, Essay on the Strength of Timber, Remarks on the Growth of Timber, &c. By W. RICHARDSON. Fcap. 8vo, 3s. 6d. cloth.

"This handy manual contains much valuable information for the use of timber merchants, builders, foresters, and all others connected with the growth, sale, and manufacture of timber."—*Journal of Forestry*.

Timber Freight Book.

THE TIMBER MERCHANT'S, SAW MILLER'S, AND IMPORTER'S FREIGHT BOOK AND ASSISTANT. Comprising Rules, Tables, and Memoranda relating to the Timber Trade. By WILLIAM RICHARDSON, Timber Broker; together with a Chapter on "SPEEDS OF SAW MILL MACHINERY," by M. POWIS BALE, M.I.M.E., &c. 12mo, 3s. 6d. cl. boards.

"A very useful manual of rules, tables, and memoranda relating to the timber trade. We recommend it as a compendium of calculation to all timber measurers and merchants, and as supplying a real want in the trade."—*Building News*.

Packing-Case Makers, Tables for.

PACKING-CASE TABLES; showing the number of Superficial Feet in Boxes or Packing-Cases, from six inches square and upwards. By W. RICHARDSON, Timber Broker. Third Edition. Oblong 4to, 3s. 6d. cl.

"Invaluable labour-saving tables."—*Ironmonger*.

"Will save much labour and calculation."—*Grocer*.

Superficial Measurement.

THE TRADESMAN'S GUIDE TO SUPERFICIAL MEASUREMENT. Tables calculated from 1 to 200 inches in length, by 1 to 108 inches in breadth. For the use of Architects, Surveyors, Engineers, Timber Merchants, Builders, &c. By JAMES HAWKINGS. Fourth Edition. Fcap., 3s. 6d. cloth.

"A useful collection of tables to facilitate rapid calculation of surfaces. The exact area of any surface of which the limits have been ascertained can be instantly determined. The book will be found of the greatest utility to all engaged in building operations."—*Scotsman*.

"These tables will be found of great assistance to all who require to make calculations in superficial measurement."—*English Mechanic*.

Forestry.

THE ELEMENTS OF FORESTRY. Designed to afford Information concerning the Planting and Care of Forest Trees for Ornament or Profit, with Suggestions upon the Creation and Care of Woodlands. By F. B. HOUGH. Large crown 8vo, 10s. cloth.

Timber Importer's Guide.

THE TIMBER IMPORTER'S, TIMBER MERCHANT'S, AND BUILDER'S STANDARD GUIDE. By RICHARD E. GRANDY. Comprising an Analysis of Deal Standards, Home and Foreign, with Comparative Values and Tabular Arrangements for fixing Net Landed Cost on Baltic and North American Deals, including all intermediate Expenses, Freight, Insurance, &c. &c. Together with copious Information for the Retailer and Builder. Third Edition, Revised. 12mo, 2s. cloth limp.

"Everything it pretends to be: built up gradually, it leads one from a forest to a treesell, and throws in, as a makeweight, a host of material concerning bricks, columns, cisterns, &c."—*English Mechanic*.

DECORATIVE ARTS, etc.

Woods and Marbles (Imitation of).

SCHOOL OF PAINTING FOR THE IMITATION OF WOODS

AND MARBLES, as Taught and Practised by A. R. VAN DER BURG and P. VAN DER BURG, Directors of the Rotterdam Painting Institution. Royal folio, 18½ by 12½ in., Illustrated with 24 full-size Coloured Plates; also 12 plain Plates, comprising 154 Figures. Second and Cheaper Edition. Price £1 11s. 6d.

List of Plates.

1. Various Tools required for Wood Painting—2, 3. Walnut: Preliminary Stages of Graining and Finished Specimen—4. Tools used for Marble Painting and Method of Manipulation—5, 6. St. Kemi Marble: Earlier Operations and Finished Specimen—7. Methods of Sketching different Grains, Knots, &c.—8, 9. Ash: Preliminary Stages and Finished Specimen—10. Methods of Sketching Marble Grains—11, 12. Breche Marble: Preliminary Stages of Working and Finished Specimen—13. Maple: Methods of Producing the different Grains—14, 15. Bird's-eye Maple: Preliminary Stages and Finished Specimen—16. Methods of Sketching the different Species of White Marble—17, 18. White Marble: Preliminary Stages of Process and

Finished Specimen—19. Mahogany: Specimens of various Grains and Methods of Manipulation—20, 21. Mahogany: Earlier Stages and Finished Specimen—22, 23, 24. Sienna Marble: Varieties of Grain, Preliminary Stages and Finished Specimen—25, 26, 27. Juniper Wood: Methods of producing Grain, &c.: Preliminary Stages and Finished Specimen—28, 29, 30. Vert de Mer Marble: Varieties of Grain and Methods of Working Unfinished and Finished Specimens—31, 32, 33. Oak: Varieties of Grain, Tools Employed, and Methods of Manipulation, Preliminary Stages and Finished Specimen—34, 35, 36. Wainsort Marble: Varieties of Grain, Unfinished and Finished Specimens.

* * * OPINIONS OF THE PRESS.

"Those who desire to attain skill in the art of painting woods and marbles will find advantage in consulting this book. . . . Some of the Working Men's Clubs should give their young men the opportunity to study it."—*Builder*.

"A comprehensive guide to the art. The explanations of the processes, the manipulation and management of the colours, and the beautifully executed plates will not be the least valuable to the student who aims at making his work a faithful transcript of nature."—*Building News*.

House Decoration.

ELEMENTARY DECORATION. A Guide to the Simpler Forms of Everyday Art, as applied to the Interior and Exterior Decoration of Dwelling Houses, &c. Together with **PRACTICAL HOUSE DECORATION**: A Guide to the Art of Ornamental Painting, the Arrangement of Colours in Apartments, and the principles of Decorative Design. By JAMES W. FACEY. With numerous Illustrations. In One Vol., 5s. strongly half-bound.

House Painting, Graining, etc.

HOUSE PAINTING, GRAINING, MARBLING, AND SIGN WRITING, A Practical Manual of. By ELLIS A. DAVIDSON. Sixth Edition. With Coloured Plates and Wood Engravings. 12mo, 6s. cloth boards.

"A mass of information, of use to the amateur and of value to the practical man."—*English Mechanic*.

"Simply invaluable to the youngster entering upon this particular calling, and highly serviceable to the man who is practising it."—*Furniture Gazette*.

Decorators, Receipts for.

THE DECORATOR'S ASSISTANT: A Modern Guide to Decorative Artists and Amateurs, Painters, Writers, Gilders, &c. Containing upwards of 600 Receipts, Rules and Instructions; with a variety of Information for General Work connected with every Class of Interior and Exterior Decorations, &c. Fifth Edition, Revised. 152 pp., crown 8vo, 1s. in wrapper.

"Full of receipts of value to decorators, painters, gilders, &c. The book contains the gist of larger treatises on colour and technical processes. It would be difficult to meet with a work so full of varied information on the painter's art."—*Building News*.

Moyr Smith on Interior Decoration.

ORNAMENTAL INTERIORS, ANCIENT AND MODERN.

By J. MOYR SMITH. Super-royal 8vo, with 32 full-page Plates and numerous smaller Illustrations, handsomely bound in cloth, gilt top, price 18s.

"The book is well illustrated and handsomely got up, and contains some true criticism and a good many good examples of decorative treatment."—*The Builder*.

"To all who take an interest in elaborate domestic ornament this handsome volume will be welcome."—*Graphic*.

British and Foreign Marbles.

MARBLE DECORATION and the Terminology of British and Foreign Marbles. A Handbook for Students. By GEORGE H. BLAGROVE, Author of "Shoring and its Application," &c. With 28 Illustrations. Crown 8vo, 3s. 6d. cloth.

"This most useful and much wanted handbook should be in the hands of every architect and builder."—*Building World*.

"A carefully and usefully written treatise; the work is essentially practical."—*Scotsman*.

Marble Working, etc.

MARBLE AND MARBLE WORKERS: A Handbook for Architects, Artists, Masons, and Students. By ARTHUR LEE, Author of "A Visit to Carrara," "The Working of Marble," &c. Small crown 8vo, 2s. cloth.

"A really valuable addition to the technical literature of architects and masons."—*Building News*.

DELAMOTTE'S WORKS ON ILLUMINATION AND ALPHABETS.

A PRIMER OF THE ART OF ILLUMINATION, for the Use of Legions: with a Rudimentary Treatise on the Art, Practical Directions for its Exercise, and Examples taken from Illuminated MSS., printed in Gold and Colours. By F. DELAMOTTE. New and Cheaper Edition. Small 4to, 6s. ornamental boards.

"The examples of ancient MSS. recommended to the student, which, with much good sense, the author chooses from collections accessible to all, are selected with judgment and knowledge, as well as taste."—*Athenaeum*.

ORNAMENTAL ALPHABETS, Ancient and Mediæval, from the Eighth Century, with Numerals; including Gothic, Church-Text, large and small, German, Italian, Arabesque, Initials for Illumination, Monograms, Crosses, &c. &c., for the use of Architectural and Engineering Draughtsmen, Missal Painters, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c. &c. Collected and Engraved by F. DELAMOTTE, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, 2s. 6d. ornamental boards.

"For those who insert enamelled sentences round gilded chalices, who blazon shop legends over shop-doors, who letter church walls with pithy sentences from the Decalogue, this book will be useful."—*Athenaeum*.

EXAMPLES OF MODERN ALPHABETS, Plain and Ornamental; including German, Old English, Saxon, Italic, Perspective, Greek, Hebrew, Court Hand, Engrossing, Tuscan, Riband, Gothic, Rustic, and Arabesque; with several Original Designs, and an Analysis of the Roman and Old English Alphabets, large and small, and Numerals, for the use of Draughtsmen, Surveyors, Masons, Decorative Painters, Lithographers, Engravers, Carvers, &c. Collected and Engraved by F. DELAMOTTE, and printed in Colours. New and Cheaper Edition. Royal 8vo, oblong, 2s. 6d. ornamental boards.

"There is comprised in it every possible shape into which the letters of the alphabet and numerals can be formed, and the talent which has been expended in the conception of the various plain and ornamental letters is wonderful."—*Standard*.

MEDIÆVAL ALPHABETS AND INITIALS FOR ILLUSTRATORS. By F. G. DELAMOTTE. Containing 21 Plates and Illuminated Title, printed in Gold and Colours. With an Introduction by J. WILLIS BROOKS. Fourth and Cheaper Edition. Small 4to, 4s. ornamental boards.

"A volume in which the letters of the alphabet come forth glorified in gilding and all the colours of the prism interwoven and intertwined and intermingled."—*Sun*.

THE EMBROIDERER'S BOOK OF DESIGN. Containing Initials, Emblems, Cyphers, Monograms, Ornamental Borders, Ecclesiastical Devices, Mediæval and Modern Alphabets, and National Emblems. Collected by F. DELAMOTTE, and printed in Colours. Oblong royal 8vo, 1s. 6d. ornamental wrapper.

"The book will be of great assistance to ladies and young children who are endowed with the art of plying the needle in this most ornamental and useful pretty work."—*East Anglian Times*.

Wood Carving.

INSTRUCTIONS IN WOOD-CARVING, for Amateurs; with Hints on Design. By A LADY. With Ten Plates. New and Cheaper Edition. Crown 8vo, 2s. in emblematic wrapper.

"The handicraft of the wood-carver, so well as a book can impart it, may be learnt from 'A Lady's publication.'"—*Athenaeum*.

NATURAL SCIENCE, etc.

The Heavens and their Origin.

THE VISIBLE UNIVERSE: Chapters on the Origin and Construction of the Heavens. By J. E. GORE, F.R.A.S., Author of "Star Groups," &c. Illustrated by 6 Stellar Photographs and 12 Lithographic Plates. Demy 8vo, 16s. cloth, gilt top. [Just published.]

"A valuable and lucid summary of recent astronomical theory, rendered more valuable and attractive by a series of stellar photographs and other illustrations."—*The Times*.

"In presenting a clear and concise account of the present state of our knowledge, Mr. Gore has made a valuable addition to the literature of the subject."—*Nature*.

"Mr. Gore's 'Visible Universe' is one of the finest works on astronomical science that has recently appeared in our language. In spirit and in method it is scientific from cover to cover, but the style is so clear and attractive that it will be as acceptable and as readable to those who make no scientific pretensions as to those who devote themselves specially to matters astronomical."—*Leeds Mercury*.

"We are glad to bear witness to the fulness, the accuracy, and the entire honesty of the latest and the best compilation of the kind which has appeared of late years. . . . The illustrations are also admirable."—*Daily Chronicle*.

"As interesting as a novel, and instructive withal; the text being made still more luminous by stellar photographs and other illustrations. . . . A most valuable book."—*Manchester Examiner*.

The Constellations.

STAR GROUPS: *A Student's Guide to the Constellations.* By J. ELLARD GORE, F.R.A.S., M.R.I.A., &c., Author of "The Visible Universe,"

"The Scenery of the Heavens." With 30 Maps. Small 4to, 5s. cloth, silvered.

"A knowledge of the principal constellations visible in our latitudes may be easily acquired by the thirty maps and accompanying text contained in this work."—*Nature*.

"The volume contains thirty maps showing stars of the sixth magnitude—the usual naked-eye limit—and each is accompanied by a brief commentary, adapted to facilitate recognition and bring to notice objects of special interest. For the purpose of a preliminary survey of the 'midnight pomp' of the heavens, nothing could be better than a set of delineations averaging scarcely twenty square inches in area, and including nothing that cannot at once be identified."—*Saturday Review*.

"A very compact and handy guide to the constellations."—*Athenaeum*.

The Microscope.

THE MICROSCOPE: Its Construction and Management, including Technique, Photo-micrography, and the Past and Future of the Microscope. By Dr. HENRI VAN HEURCK, Director of the Antwerp Botanical Gardens. English Edition, Re-Edited and Augmented by the Author from the Fourth French Edition, and Translated by WYNN E. BAXTER, F.R.M.S., F.G.S., &c. About 400 pages, with Three Plates and upwards of 250 Woodcuts. Imp. 8vo, 18s. cloth gilt. [Just published.]

"This is a translation of a well-known work, at once popular and comprehensive, on the structure, mechanism, and use of the microscope. Of adequate English manuals on the use of the microscope there is certainly no lack; but, as the translator very truly says, such a book as Professor van Heurck's must necessarily be of interest to all who devote serious attention to microscopic work as a means of comparing the continental views and modes of thought with those of their own and other countries."—*Times*.

Astronomy.

ASTRONOMY. By the late Rev. ROBERT MAIN, M.A., F.R.S., formerly Radcliffe Observer at Oxford. Third Edition, Revised and Corrected to the present time, by WILLIAM THYNNE LYNN, B.A., F.R.A.S., formerly of the Royal Observatory, Greenwich. 12mo, 2s. cloth limp.

"A sound and simple treatise, very carefully edited, and a capital book for beginners."—*Knowledge*.

"Accurately brought down to the requirements of the present time by Mr. Lynn."—*Education Times*.

Recent and Fossil Shells.

A MANUAL OF THE MOLLUSCA: *Being a Treatise on Recent and Fossil Shells.* By S. P. WOODWARD, A.L.S., F.G.S., late Assistant Palaeontologist in the British Museum. With an Appendix on *Recent and Fossil Conchological Discoveries*, by RALPH TATE, A.L.S., F.G.S. Illustrated by A. N. WATERHOUSE and JOSEPH WILSON LOWRY. With 23 Plates and upwards of 300 Woodcuts. Reprint of Fourth Ed., 1880. Cr. 8vo, 7s. 6d. cl.

"A most valuable storehouse of conchological and geological information."—*Science Gossip*.

Geology and Genesis.

THE TWIN RECORDS OF CREATION; *or, Geology and Genesis: their Perfect Harmony and Wonderful Concord.* By GEORGE W. VICTOR LE VAUX. Numerous Illustrations. Fcap. 8vo, 5s. cloth.

"A valuable contribution to the evidences of Revelation, and disposes very conclusively of the arguments of those who would set God's Works against God's Word. No real difficulty is shirked and no sophistry is left unexposed."—*The Rock*.

DR. LARDNER'S COURSE OF NATURAL PHILOSOPHY.

THE HANDBOOK OF MECHANICS. Enlarged and almost rewritten by BENJAMIN LOEWY, F.R.A.S. With 378 Illustrations. Post 8vo, 6s. cloth.

"The perspicuity of the original has been retained, and chapters which had become obsolete have been replaced by others of more modern character. The explanations throughout are studiously popular, and care has been taken to show the application of the various branches of physics to the industrial arts, and to the practical business of life."—*Mining Journal*.

"Mr. Loewy has carefully revised the book, and brought it up to modern requirements."—*Nature*.

"Natural philosophy has had few exponents more able or better skilled in the art of popularising the subject than Dr. Lardner; and Mr. Loewy is doing good service in fitting this treatise, and the others of the series, for use at the present time."—*Scotsman*.

THE HANDBOOK OF HYDROSTATICS AND PNEUMATICS.

New Edition, Revised and Enlarged, by BENJAMIN LOEWY, F.R.A.S. With 236 Illustrations. Post 8vo, 5s. cloth.

"For those 'who desire to attain an accurate knowledge of physical science without the profound methods of mathematical investigation,' this work is not merely intended, but well adapted."—*Chemical News*.

"The volume before us has been carefully edited, augmented to nearly twice the bulk of the former edition, and all the most recent matter has been added. . . . It is a valuable text-book."—*Nature*.

"Candidates for pass examinations will find it, we think, specially suited to their requirements."—*English Mechanic*.

THE HANDBOOK OF HEAT. Edited and almost entirely Rewritten by BENJAMIN LOEWY, F.R.A.S., &c. 117 Illusts. Post 8vo, 6s. cloth.

"The style is always clear and precise, and conveys instruction without leaving any cloudiness or lurking doubts behind."—*Engineering*.

"A most exhaustive book on the subject on which it treats, and is so arranged that it can be understood by all who desire to attain an accurate knowledge of physical science. . . . Mr. Loewy has included all the latest discoveries in the varied laws and effects of heat."—*Standard*.

"A complete and handy text-book for the use of students and general readers."—*English Mechanic*.

THE HANDBOOK OF OPTICS. By DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. New Edition. Edited by T. OLVER HARDING, B.A. Lond., of University College, London. With 298 Illustrations. Small 8vo, 448 pages, 5s. cloth.

"Written by one of the ablest English scientific writers, beautifully and elaborately illustrated."—*Mechanic's Magazine*.

THE HANDBOOK OF ELECTRICITY, MAGNETISM, AND ACOUSTICS. By Dr. LARDNER. Ninth Thousand. Edit. by GEORGE CAREY FOSTER, B.A., F.C.S. With 400 Illustrations. Small 8vo, 5s. cloth.

"The book could not have been entrusted to anyone better calculated to preserve the terse and lucid style of Lardner, while correcting his errors and bringing up his work to the present state of scientific knowledge."—*Popular Science Review*.

THE HANDBOOK OF ASTRONOMY. Forming a Companion to the "Handbook of Natural Philosophy." By DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. Fourth Edition, Revised and Edited by EDWIN DUNKIN, F.R.A.S., Royal Observatory, Greenwich. With 38 Plates and upwards of 200 Woodcuts. In One Vol., small 8vo, 550 pages, 9s. 6d. cloth.

"Probably no other book contains the same amount of information in so compendious and well-arranged a form—certainly none at the price at which this is offered to the public."—*Athenæum*.

"We can do no other than pronounce this work a most valuable manual of astronomy, and we strongly recommend it to all who wish to acquire a general—but at the same time correct—acquaintance with this sublime science."—*Quarterly Journal of Science*.

"One of the most deservedly popular books on the subject. . . . We would recommend not only the student of the elementary principles of the science, but he who aims at mastering the higher and mathematical branches of astronomy, not to be without this work beside him."—*Practical Magazine*.

Geology.

RUDIMENTARY TREATISE ON GEOLOGY, PHYSICAL

AND HISTORICAL. Consisting of "Physical Geology," which sets forth the leading Principles of the Science; and "Historical Geology," which treats of the Mineral and Organic Conditions of the Earth at each successive epoch, especial reference being made to the British Series of Rocks. By RALPH TATE, A.L.S., F.G.S., &c. With 250 Illustrations. 12mo, 5s. cl. bds.

"The fulness of the matter has elevated the book into a manual. Its information is exhaustive and well arranged."—*School Board Chronicle*.

DR. LARDNER'S MUSEUM OF SCIENCE AND ART.

THE MUSEUM OF SCIENCE AND ART. Edited by DIONYSIUS LARDNER, D.C.L., formerly Professor of Natural Philosophy and Astronomy in University College, London. With upwards of 1,300 Engravings on Wood. In 6 Double Volumes, £1 1s. in a new and elegant cloth binding; or handsomely bound in half-morocco, 31s. 6d.

. OPINIONS OF THE PRESS.

"This series, besides affording popular but sound instruction on scientific subjects, with which the humblest man in the country ought to be acquainted, also undertakes that teaching of 'Common Things' which every well-wisher of his kind is anxious to promote. Many thousand copies of this serviceable publication have been printed, in the belief and hope that the desire for instruction and improvement widely prevails; and we have no fear that such enlightened faith will meet with disappointment."—*Times*.

"A cheap and interesting publication, alike informing and attractive. The papers combine subjects of importance and great scientific knowledge, considerable inductive powers, and a popular style of treatment."—*Spectator*.

"The 'Museum of Science and Art' is the most valuable contribution that has ever been made to the Scientific Instruction of every class of society."—Sir DAVID BREWSTER, in the *North British Review*.

"Whether we consider the liberality and beauty of the illustrations, the charm of the writing, or the durable interest of the matter, we must express our belief that there is hardly to be found among the new books one that would be welcomed by people of so many ages and classes as a valuable present."—*Examiner*.

. *Separate books formed from the above, suitable for Workmen's Libraries, Science Classes, &c.*

Common Things Explained. Containing Air, Earth, Fire, Water, Time, Man, the Eye, Locomotion, Colour, Clocks and Watches, &c. 333 Illustrations, cloth gilt, 3s.

The Microscope. Containing Optical Images, Magnifying Glasses, Origin and Description of the Microscope, Microscopic Objects, the Solar Microscope, Microscopic Drawing and Engraving, &c. 147 Illustrations, cloth gilt, 2s.

Popular Geology. Containing Earthquakes and Volcanoes, the Crust of the Earth, &c. 201 Illustrations, cloth gilt, 2s. 6d.

Popular Physics. Containing Magnitude and Minuteness, the Atmosphere, Meteoric Stones, Popular Fallacies, Weather Prognostics, the Thermometer, the Barometer, Sound, &c. 85 Illustrations, cloth gilt, 2s. 6d.

Steam and its Uses. Including the Steam Engine, the Locomotive, and Steam Navigation. 89 Illustrations, cloth gilt, 2s.

Popular Astronomy. Containing How to observe the Heavens—The Earth, Sun, Moon, Planets, Light, Comets, Eclipses, Astronomical Influences, &c. 182 Illustrations, cloth gilt, 4s. 6d.

The Bee and White Ants: Their Manners and Habits. With Illustrations of Animal Instinct and Intelligence. 135 Illustrations, cloth gilt, 2s.

The Electric Telegraph Popularised. To render intelligible to all who can read, irrespective of any previous Scientific Acquirements, the various forms of Telegraphy in Actual Operation. 100 Illustrations, cloth gilt, 1s. 6d.

Dr. Lardner's School Handbooks.

NATURAL PHILOSOPHY FOR SCHOOLS. By Dr. LARDNER. 328 Illustrations. Sixth Edition. One Vol., 3s. 6d. cloth.

"A very convenient class-book for junior students in private schools. It is intended to convey clearer and precise terms, general notions of all the principal divisions of Physical Science."—*British Quarterly Review*.

ANIMAL PHYSIOLOGY FOR SCHOOLS. By Dr. LARDNER. With 190 Illustrations. Second Edition. One Vol., 3s. 6d. cloth.

"Clearly written, well arranged, and excellently illustrated."—*Gardner's Chronicle*.

Lardner and Bright on the Electric Telegraph.

THE ELECTRIC TELEGRAPH. By Dr. LARDNER. Revised and Re-written by E. B. BRIGHT, F.R.A.S. 140 Illustrations. Small 8vo, 2s. 6d. cloth.

"One of the most readable books extant on the Electric Telegraph."—*English Mechanic*.

CHEMICAL MANUFACTURES, CHEMISTRY.

Alkali Trade, Manufacture of Sulphuric Acid, etc.

A MANUAL OF THE ALKALI TRADE, including the Manufacture of Sulphuric Acid, Sulphate of Soda, and Bleaching Powder. By JOHN LOMAS, Alkali Manufacturer, Newcastle-upon-Tyne and London. With 232 Illustrations and Working Drawings, and containing 390 pages of Text. Second Edition, with Additions. Super-royal 8vo, £1 10s. cloth.

"This book is written by a manufacturer for manufacturers. The working details of the most approved forms of apparatus are given, and these are accompanied by no less than 232 wood engravings, all of which may be used for the purposes of construction. Every step in the manufacture is very fully described in this manual, and each improvement explained."—*Athenæum*.

"We find not merely a sound and luminous explanation of the chemical principles of the trade, but a notice of numerous matters which have a most important bearing on the successful conduct of alkali works, but which are generally overlooked by even experienced technological authors."—*Chemical Review*.

The Blowpipe.

THE BLOWPIPE IN CHEMISTRY, MINERALOGY, AND GEOLOGY. Containing all known Methods of Anhydrous Analysis, many Working Examples, and Instructions for Making Apparatus. By Lieut.-Colonel W. A. ROSS, R.A., F.G.S. With 120 Illustrations. Second Edition, Revised and Enlarged. Crown 8vo, 5s. cloth.

"The student who goes conscientiously through the course of experimentation here laid down will gain a better insight into inorganic chemistry and mineralogy than if he had 'got up' any of the best text-books of the day, and passed any number of examinations in their contents."—*Chemical News*.

Commercial Chemical Analysis.

THE COMMERCIAL HANDBOOK OF CHEMICAL ANALYSIS; or, Practical Instructions for the determination of the Intrinsic or Commercial Value of Substances used in Manufactures, in Trades, and in the Arts. By A. NORMANDY, Editor of Rose's "Treatise on Chemical Analysis." New Edition, to a great extent re-written by HENRY M. NOAD, Ph.D., F.R.S. With numerous Illustrations. Crown 8vo, 12s. 6d. cloth.

"We strongly recommend this book to our readers as a guide, alike indispensable to the housewife as to the pharmaceutical practitioner."—*Medical Times*.

"Essential to the analysts appointed under the new Act. The most recent results are given, and the work is well edited and carefully written."—*Nature*.

Chemistry for Engineers, etc.

ENGINEERING CHEMISTRY: A Practical Treatise for the Use of Analytical Chemists, Engineers, Iron Masters, Iron Founders, Students, and others. Comprising Methods of Analysis and Valuation of the Principal Materials used in Engineering Work, with numerous Analyses, Examples, and Suggestions. By H. JOSHUA PHILLIPS, F.I.C., F.C.S. Analytical and Consulting Chemist to the Great Eastern Railway. Crown 8vo, 320 pp., with Illustrations, 10s. 6d. cloth. [Just published.]

"In this work the author has rendered no small service to a numerous body of practical men. . . . The analytical methods may be pronounced most satisfactory, being as accurate as the despatch required of engineering chemists permits."—*Chemical News*.

"Those in search of a handy treatise on the subject of analytical chemistry as applied to the every-day requirements of workshop practice will find this volume of great assistance."—*Iron*.

"The first attempt to bring forward a Chemistry specially written for the use of engineers, and we have no hesitation whatever in saying that it should at once be in the possession of every railway engineer."—*The Railway Engineer*.

"The book will be very useful to those who require a handy and concise resume of approved methods of analysing and valuing metals, oils, fuels, &c. It is, in fact, a work for chemists, a guide to the routine of the engineering laboratory. . . . The book is full of good things. As a handbook of technical analysis, it is very welcome."—*Builder*.

Dye-Wares and Colours.

THE MANUAL OF COLOURS AND DYE-WARES: Their Properties, Applications, Valuations, Impurities, and Sophistications. For the use of Dyers, Printers, Drysalts, Brokers, &c. By J. W. SLATER. Second Edition, Revised and greatly Enlarged. Crown 8vo, 7s. 6d. cloth.

"A complete encyclopædia of the *matéria tinctoria*. The information given respecting each article is full and precise, and the methods of determining the value of articles such as these, so liable to sophistication, are given with clearness, and are practical as well as valuable."—*Chemist and Druggist*.

"There is no other work which covers precisely the same ground. To students preparing for examinations in dyeing and printing it will prove exceedingly useful."—*Chemical News*.

Modern Brewing and Malting.

A HANDYBOOK FOR BREWERS: Being a Practical Guide to the Art of Brewing and Malting. Embracing the Conclusions of Modern Research which bear upon the Practice of Brewing. By HERBERT EDWARDS WRIGHT, M.A., Author of "A Handbook for Young Brewers." Crown 8vo, 530 pp., 12s. 6d. cloth. [Just published.

"May be consulted with advantage by the student who is preparing himself for examination tests, while the scientific brewer will find in it a *resumé* of all the most important discoveries of modern times. The work is written throughout in a clear and concise manner, and the author takes great care to discriminate between vague theories and well-established facts."—*Brewers' Journal*.

"We have very great pleasure in recommending this handybook, and have no hesitation in saying that it is one of the best—if not the best—which has yet been written on the subject of beer-brewing in this country, and it should have a place on the shelves of every brewer's library."—*The Brewer's Guardian*.

"Well arranged, under special headings which separate each paragraph, and furnished with a good index, every facility for speedy reference is afforded. . . . On every debatable subject we have presented in an unbiased fashion the opinions which have been advanced in explanation of these points, making the work exactly what it purports to be, a comprehensive review of the conclusions of modern research in regard to brewing."—*Chemical Trade Journal*.

Analysis and Valuation of Fuels.

FUELS: SOLID, LIQUID, AND GASEOUS, Their Analysis and Valuation. For the Use of Chemists and Engineers. By H. J. PHILLIPS, F.C.S., Analytical and Consulting Chemist to the Great Eastern Railway, Author of "Engineering Chemistry," &c. Second Edition, Revised and Enlarged. Crown 8vo, 5s. cloth. [Just published.

"Ought to have its place in the laboratory of every metallurgical establishment, and wherever fuel is used on a large scale."—*Chemical News*.

"Mr. Phillips' new book cannot fail to be of wide interest, especially at the present time."—*Railway News*.

Pigments.

THE ARTIST'S MANUAL OF PIGMENTS. Showing their Composition, Conditions of Permanency, Non-Permanency, and Adulterations; Effects in Combination with Each Other and with Vehicles; and the most Reliable Tests of Purity. Together with the Science and Arts Department's Examination Questions on Painting. By H. C. STANDAGE. Second Edition, crown 8vo, 2s. 6d. cloth.

"This work is indeed *multum in parvo*, and we can, with good conscience, recommend it to all who come in contact with pigments, whether as makers, dealers or users."—*Chemical Review*.

Gauging. Tables and Rules for Revenue Officers, Brewers, &c.

A POCKET BOOK OF MENSURATION AND GAUGING: Containing Tables, Rules and Memoranda for Revenue Officers, Brewers, Spirit Merchants, &c. By J. B. MANT (Inland Revenue). Second Edition, Revised. Oblong 18mo, 4s. leather, with elastic band.

"This handy and useful book is adapted to the requirements of the Inland Revenue Department, and will be a favourite book of reference. The range of subjects is comprehensive, and the arrangement simple and clear."—*Civilian*.

"Should be in the hands of every practical brewer."—*Brewers' Journal*.

INDUSTRIAL ARTS, TRADES, AND MANUFACTURES.**Flour Manufacture, Milling, &c.**

FLOUR MANUFACTURE: A Treatise on Milling Science and Practice. By FRIEDRICH KICK, Imperial Regierungsrath, Professor of Mechanical Technology in the Imperial German Polytechnic Institute, Prague. Translated from the Second Enlarged and Revised Edition with Supplement. By H. H. P. POWLES, Assoc. Memb. Institution of Civil Engineers. Nearly 400 pp. Illustrated with 28 Folding Plates, and 167 Woodcuts. Royal 8vo, 25s. cloth.

"This valuable work is, and will remain, the standard authority on the science of milling. . . . The miller who has read and digested this work will have laid the foundation, so to speak, of a successful career; he will have acquired a number of general principles which he can proceed to apply. In this handsome volume we at last have the accepted text-book of modern milling in good, sound English, which has little, if any, trace of the German idiom."—*The Miller*.

"The appearance of this celebrated work in English is very opportune, and British millers will, we are sure, not be slow in availing themselves of its pages."—*Millers' Gazette*.

Soap-making.

THE ART OF SOAP-MAKING: A Practical Handbook of the Manufacture of Hard and Soft Soaps, Toilet Soaps, etc. Including many New Processes, and a Chapter on the Recovery of Glycerine from Waste Lays. By ALEXANDER WATT, Author of "Electro-Metallurgy Practically Treated," &c. With numerous Illustrations. Fourth Edition, Revised and Enlarged. Crown 8vo, 7s. 6d. cloth.

"The work will prove very useful, not merely to the technological student, but to the practical soap-boiler who wishes to understand the theory of his art."—*Chemical News*.

"Really an excellent example of a technical manual, entering, as it does, thoroughly and exhaustively, both into the theory and practice of soap manufacture. The book is well and honestly done, and deserves the considerable circulation with which it will doubtless meet."—*Knowledge*.

"Mr. Watt's book is a thoroughly practical treatise on an art which has almost no literature in our language. We congratulate the author on the success of his endeavour to fill a void in English technical literature."—*Nature*.

Paper Making.

THE ART OF PAPER MAKING: A Practical Handbook of the Manufacture of Paper from Rags, Esparto, Straw, and other Fibrous Materials, Including the Manufacture of Pulp from Wood Fibre, with a Description of the Machinery and Appliances used. To which are added Details of Processes for Recovering Soda from Waste Liquors. By ALEXANDER WATT, Author of "The Art of Soap-Making," "The Art of Leather Manufacture," &c. With Illustrations. Crown 8vo, 7s. 6d. cloth.

"This book is succinct, lucid, thoroughly practical, and includes everything of interest to the modern paper-maker. The book, besides being all the student of paper-making will require in his apprenticeship, will be found of interest to the paper-maker himself. It is the latest, most practical, and most complete work on the paper-making art before the British public."—*Paper Record*.

"It may be regarded as the standard work on the subject. The book is full of valuable information. The 'Art of Paper-making,' is in every respect a model of a text-book, either for a technical class or for the private student."—*Paper and Printing Trades Journal*.

Leather Manufacture.

THE ART OF LEATHER MANUFACTURE. Being a Practical Handbook, in which the Operations of Tanning, Currying, and Leather Dressing are fully Described, and the Principles of Tanning Explained, and many Recent Processes Introduced; as also the Methods for the Estimation of Tannin, and a Description of the Arts of Glue Boiling, Gut Dressing, &c. By ALEXANDER WATT, Author of "Soap-Making," "Electro-Metallurgy," &c. With numerous Illustrations. Second Edition. Crown 8vo, 9s. cloth.

"A sound, comprehensive treatise on tanning and its accessories. The book is an eminently valuable production, which redounds to the credit of both author and publishers."—*Chemical Review*.

"This volume is technical without being tedious, comprehensive and complete without being prosy, and it bears on every page the impress of a master hand. We have never come across a better trade treatise, nor one that so thoroughly supplied an absolute want."—*Shoe and Leather Trades Chronicle*.

Boot and Shoe Making.

THE ART OF BOOT AND SHOE-MAKING. A Practical Handbook, including Measurement, Last-Fitting, Cutting-Out, Closing, and Making, with a Description of the most approved Machinery employed. By JOHN B. LENO, late Editor of *St. Crispin*, and *The Boot and Shoe-Maker*. With numerous Illustrations. Third Edition. 12mo, 2s. cloth limp.

"This excellent treatise is by far the best work ever written on the subject. The chapter on clicking, which shows how waste may be prevented, will save fifty times the price of the book."—*Scottish Leather Trader*.

Dentistry Construction.

MECHANICAL DENTISTRY: A Practical Treatise on the Construction of the various kinds of Artificial Dentures. Comprising also Useful Formulæ, Tables, and Receipts for Gold Plate, Clasps, Solders, &c. &c. By CHARLES HUNTER. Third Edition, Revised. With upwards of 100 Wood Engravings. Crown 8vo, 3s. 6d. cloth.

"The work is very practical."—*Monthly Review of Dental Surgery*.

"We can strongly recommend Mr. Hunter's treatise to all students preparing for the profession of dentistry, as well as to every mechanical dentist."—*Dublin Journal of Medical Science*.

Wood Engraving.

WOOD ENGRAVING: A Practical and Easy Introduction to the Study of the Art. By WILLIAM NORMAN BROWN. Second Edition. With numerous Illustrations. 12mo, 1s. 6d. cloth limp.

"The book is clear and complete, and will be useful to anyone wanting to understand the first elements of the beautiful art of wood engraving."—*Graphic*.

Horology.

A TREATISE ON MODERN HOROLOGY, in Theory and Practice. Translated from the French of CLAUDIUS SAUNIER, ex-Director of the School of Horology at Maçon, by JULIEN TRIPLIN, F.R.A.S., Besançon Watch Manufacturer, and EDWARD RIGG, M.A., Assayer in the Royal Mint. With 78 Woodcuts and 22 Coloured Copper Plates. Second Edition. Super-royal 8vo, £2 2s. cloth; £2 10s. half-calf.

"There is no horological work in the English language at all to be compared to this production of M. Saunier's for clearness and completeness. It is alike good as a guide for the student and as a reference for the experienced horologist and skilled workman."—*Horological Journal*.

"The latest, the most complete, and the most reliable of those literary productions to which continental watchmakers are indebted for the mechanical superiority over their English brethren—in fact, the Book of Books, is M. Saunier's 'Treatise.'"—*Watchmaker, Jeweller and Silversmith*.

Watchmaking.

THE WATCHMAKER'S HANDBOOK. Intended as a Workshop Companion for those engaged in Watchmaking and the Allied Mechanical Arts. Translated from the French of CLAUDIUS SAUNIER, and considerably enlarged by JULIEN TRIPLIN, F.R.A.S., Vice-President of the Horological Institute, and EDWARD RIGG, M.A., Assayer in the Royal Mint. With numerous Woodcuts and 14 Copper Plates. Third Edition. Crown 8vo, 9s. cloth.

"Each part is truly a treatise in itself. The arrangement is good and the language is clear and concise. It is an admirable guide for the young watchmaker."—*Engineering*.

"It is impossible to speak too highly of its excellence. It fulfils every requirement in a handbook intended for the use of a workman. Should be found in every workshop."—*Watch and Clockmaker*.

"This book contains an immense number of practical details bearing on the daily occupation of a watchmaker."—*Watchmaker and Metalworker* (Chicago).

Watches and Timekeepers.

A HISTORY OF WATCHES AND OTHER TIMEKEEPERS. By JAMES F. KENDAL, M.B.H.Inst. 250 pp., with 88 Illustrations, 1s. 6d. boards; or 2s. 6d. cloth gilt. [Just published.]

"Mr. Kendal's book, for its size, is the best which has yet appeared on this subject in the English language."—*Industries*.

"Open the book where you may, there is interesting matter in it concerning the ingenious devices of the ancient or modern horologist. The subject is treated in a liberal and entertaining spirit, as might be expected of a historian who is a master of the craft."—*Saturday Review*.

Electrolysis of Gold, Silver, Copper, etc.

ELECTRO-DEPOSITION: A Practical Treatise on the Electrolysis of Gold, Silver, Copper, Nickel, and other Metals and Alloys. With descriptions of Voltaic Batteries, Magneto and Dynamo-Electric Machines, Thermopiles, and of the Materials and Processes used in every Department of the Art, and several Chapters on Electro-Metallurgy. By ALEXANDER WATT, Author of "Electro-Metallurgy," &c. With numerous Illustrations. Third Edition, Revised and Corrected. Crown 8vo, 9s. cloth.

"Eminently a book for the practical worker in electro-deposition. It contains practical descriptions of methods, processes and materials as actually pursued and used in the workshop."—*Engineer*.

Electro-Metallurgy.

ELECTRO-METALLURGY; Practically Treated. By ALEXANDER WATT, Author of "Electro-Deposition," &c. Ninth Edition, Enlarged and Revised, with Additional Illustrations, and including the most recent Processes. 12mo, 4s. cloth boards.

"From this book both amateur and artisan may learn everything necessary for the successful prosecution of electroplating."—*Iron*.

Working in Gold.

THE JEWELLER'S ASSISTANT IN THE ART OF WORKING IN GOLD: A Practical Treatise for Masters and Workmen, Compiled from the Experience of Thirty Years' Workshop Practice. By GEORGE E. GEE, Goldsmith and Silversmith, Author of "The Goldsmith's Handbook," &c. Crown 8vo, 7s. 6d. cloth. [Just published.]

"This manual of technical education is apparently destined to be a valuable auxiliary to a handicraft which is certainly capable of great improvement."—*The Times*.

"This volume will be very useful in the workshop, as the knowledge is practical, having been acquired by long experience, and all the recipes and directions are guaranteed to be successful if properly worked out."—*Jeweller and Metalworker*.

Electroplating.

ELECTROPLATING: A Practical Handbook on the Deposition of Copper, Silver, Nickel, Gold, Aluminium, Brass, Platinum, &c. &c. With Descriptions of the Chemicals, Materials, Batteries, and Dynamo Machines used in the Art. By J. W. URQUHART, C.E., Author of "Electric Light," &c. Second Edition, Revised, with Additions. Numerous Illustrations. Crown 8vo, 5s. cloth.

"An excellent practical manual."—*Engineering*.

"An excellent work, giving the newest information."—*Horological Journal*.

Electrotyping.

ELECTROTYPING: The Reproduction and Multiplication of Printing Surfaces and Works of Art by the Electro-deposition of Metals. By J. W. URQUHART, C.E. Crown 8vo, 5s. cloth.

"The book is thoroughly practical. The reader is, therefore, conducted through the leading laws of electricity, then through the metals used by electrotypers, the apparatus, and the depositing processes, up to the final preparation of the work."—*Art Journal*.

Goldsmiths' Work.

THE GOLDSMITH'S HANDBOOK. By GEORGE E. GEE, Jeweller, &c. Third Edition, considerably Enlarged. 12mo, 3s. 6d. cl. bds.

"A good, sound educator, and will be generally accepted as an authority."—*Horological Journal*.

Silversmiths' Work.

THE SILVERSMITH'S HANDBOOK. By GEORGE E. GEE, Jeweller, &c. Second Edition, Revised, with numerous Illustrations. 12mo, 3s. 6d. cloth boards.

"The chief merit of the work is its practical character. . . . The workers in the trade will speedily discover its merits when they sit down to study it."—*English Mechanic*.

* * * The above two works together, strongly half-bound, price 7s.

Bread and Biscuit Baking.

THE BREAD AND BISCUIT BAKER'S AND SUGAR-BOILER'S ASSISTANT. Including a large variety of Modern Recipes. With Remarks on the Art of Bread-making. By ROBERT WELLS, Practical Baker. Second Edition, with Additional Recipes. Crown 8vo, 2s. cloth.

"A large number of wrinkles for the ordinary cook, as well as the baker."—*Saturday Review*.

Confectionery for Hotels and Restaurants.

THE PASTRYCOOK AND CONFECTIONER'S GUIDE. For Hotels, Restaurants and the Trade in general, adapted also for Family Use. By ROBERT WELLS, Author of "The Bread and Biscuit Baker's and Sugar-Boiler's Assistant." Crown 8vo, 2s. cloth.

"We cannot speak too highly of this really excellent work. In these days of keen competition our readers cannot do better than purchase this book."—*Bakers' Times*.

Ornamental Confectionery.

ORNAMENTAL CONFECTIONERY: A Guide for Bakers, Confectioners and Pastrycooks; including a variety of Modern Recipes, and Remarks on Decorative and Coloured Work. With 129 Original Designs. By ROBERT WELLS, Practical Baker, Author of "The Bread and Biscuit Baker's and Sugar-Boiler's Assistant," &c. Crown 8vo, cloth gilt, 5s.

"A valuable work, practical, and should be in the hands of every baker and confectioner." The illustrative designs are alone worth treble the amount charged for the whole work."—*Bakers' Times*.

Flour Confectionery.

THE MODERN FLOUR CONFECTIONER. Wholesale and Retail. Containing a large Collection of Recipes for Cheap Cakes, Biscuits, &c. With Remarks on the Ingredients used in their Manufacture. To which are added Recipes for Dainties for the Working Man's Table. By R. WELLS, Author of "The Bread and Biscuit Baker," &c. Crown 8vo, 2s. cl.

"The work is of a decidedly practical character, and in every recipe regard is had to economical working."—*North British Daily Mail*.

Laundry Work.

LAUNDRY MANAGEMENT. A Handbook for Use in Private and Public Laundries, Including Descriptive Accounts of Modern Machinery and Appliances for Laundry Work. By the EDITOR of "The Laundry Journal." With numerous Illustrations. Crown 8vo, 2s. 6d. cloth.

"This book should certainly occupy an honoured place on the shelves of all housekeepers who wish to keep themselves au courant of the newest appliances and methods."—*The Queen*.

HANDYBOOKS FOR HANDICRAFTS.

By PAUL N. HASLACK,

EDITOR OF "WORK" (NEW SERIES); AUTHOR OF "LATHEWORK," "MILLING MACHINES AND PROCESSES," etc.

Crown 8vo, 144 pages, cloth, price 1s. each.

These HANDYBOOKS have been written to supply information for WORKMEN, STUDENTS, and AMATEURS in the several Handicrafts, on the actual PRACTICE of the WORKSHOP, and are intended to convey in plain language TECHNICAL KNOWLEDGE of the several CRAFTS. In describing the processes employed, and the manipulation of material, workshop terms are used; workshop practice is fully explained; and the text is freely illustrated with drawings of modern tools, appliances, and processes. The information given will thus be found useful, not only by the young beginner, but by the veteran whose range of experience has been narrowed under a system of divided labour; while the amateur will find himself introduced to the very atmosphere and surroundings of the workshop.

In view of the wide circulation which the HANDYBOOKS have already attained, and the yet wider circulation which must accrue from the facilities for MANUAL INSTRUCTION now provided by LOCAL AUTHORITIES in pursuance of recent legislation, it has been decided to issue them at the price of One Shilling each.

* * The following Volumes are now ready :

THE METAL TURNER'S HANDYBOOK. A Practical Manual for Workers at the Foot-Lathe. With over 100 Illustrations. Price 1s.

"The book will be of service alike to the amateur and the artisan turner. It displays thorough knowledge of the subject."—*Scotsman*.

THE WOOD TURNER'S HANDYBOOK. A Practical Manual for Workers at the Lathe. With over 100 Illustrations. Price 1s.

"We recommend the book to young turners and amateurs. A multitude of workmen have hitherto sought in vain for a manual of this special industry."—*Mechanical World*.

THE WATCH JOBBER'S HANDYBOOK. A Practical Manual on Cleaning, Repairing, and Adjusting. With upwards of 100 Illustrations. Price 1s.

"We strongly advise all young persons connected with the watch trade to acquire and study this inexpensive work."—*Clerkenwell Chronicle*.

THE PATTERN MAKER'S HANDYBOOK. A Practical Manual on the Construction of Patterns for Founders. With upwards of 100 Illustrations. Price 1s.

"A most valuable, if not indispensable, manual for the pattern maker."—*Knowledge*.

THE MECHANIC'S WORKSHOP HANDYBOOK. A Practical Manual on Mechanical Manipulation. Embracing Information on various Handicraft Processes, with Useful Notes and Miscellaneous Memoranda. Comprising about 200 Subjects. Price 1s.

"A very clever and useful book, which should be found in every workshop; and it should certainly find a place in all technical schools."—*Saturday Review*.

THE MODEL ENGINEER'S HANDYBOOK. A Practical Manual on the Construction of Model Steam Engines. With upwards of 100 Illustrations. Price 1s.

"Mr. Hasluck has produced a very good little book."—*Builder*.

THE CLOCK JOBBER'S HANDYBOOK. A Practical Manual on Cleaning, Repairing, and Adjusting. With upwards of 100 Illustrations. Price 1s.

"It is of inestimable service to those commencing the trade."—*Coventry Standard*.

THE CABINET WORKER'S HANDYBOOK: A Practical Manual on the Tools, Materials, Appliances, and Processes employed in Cabinet Work. With upwards of 100 Illustrations. Price 1s.

"Mr. Hasluck's thoroughgoing little Handybook is amongst the most practical guides we have seen for beginners in cabinet-work."—*Saturday Review*.

* The following are in preparation :

THE WOODWORKER'S HANDYBOOK.

THE METALWORKER'S HANDYBOOK.

COMMERCE, COUNTING-HOUSE WORK, TABLES, etc.

Commercial Education.

LESSONS IN COMMERCE. By Professor R. GAMBARO, of the Royal High Commercial School at Genoa. Edited and Revised by JAMES GAULT, Professor of Commerce and Commercial Law in King's College, London. Crown 8vo, 3s. 6d. cloth.

"The publishers of this work have rendered considerable service to the cause of commercial education by the opportune production of this volume. . . . The work is peculiarly acceptable to English readers and an admirable addition to existing class-books. In a phrase, we think the work attains its object in furnishing a brief account of those laws and customs of British trade with which the commercial man interested therein should be familiar."—*Chamber of Commerce Journal*.

Foreign Commercial Correspondence.

THE FOREIGN COMMERCIAL CORRESPONDENT: Being Aids to Commercial Correspondence in Five Languages—English, French, German, Italian, and Spanish. By CONRAD E. BAKER. Second Edition. Crown 8vo, 3s. 6d. cloth.

"Whoever wishes to correspond in all the languages mentioned by Mr. Baker cannot do better than study this work, the materials of which are excellent and conveniently arranged."—*Athenæum*.
 "A careful examination has convinced us that it is unusually complete, well arranged, and reliable. The book is a thoroughly good one."—*Schoolmaster*.

Accounts for Manufacturers.

FACTORY ACCOUNTS: Their Principles and Practice. A Handbook for Accountants and Manufacturers, with Appendices on the Nomenclature of Machine Details; the Income Tax Acts; the Rating of Factories; Fire and Boiler Insurance; the Factory and Workshop Acts, &c., including also a Glossary of Terms and a large number of Specimen Rulings. By EMILE GARCKE and J. M. FELS. Third Edition. Demy 8vo, 250 pages, price 6s. strongly bound.

"A very interesting description of the requirements of Factory Accounts. . . . the principle of assimilating the Factory Accounts to the general commercial books is one which we thoroughly agree with."—*Accountants' Journal*.

"Characterised by extreme thoroughness. There are few owners of factories who would not derive great benefit from the perusal of this most admirable work."—*Local Government Chronicle*

Intuitive Calculations.

THE COMPENDIOUS CALCULATOR; or, Easy and Concise Methods of Performing the various Arithmetical Operations required in Commercial and Business Transactions, together with Useful Tables. By DANIEL O'GORMAN. Corrected and Extended by Professor J. R. YOUNG. Twenty-seventh Edition, Revised by C. NORRIS. Fcap. 8vo, 2s. 6d. cloth limp; or, 3s. 6d. strongly half-bound in leather.

"It would be difficult to exaggerate the usefulness of a book like this to everyone engaged in commerce or manufacturing industry. It is crammed full of rules and formulæ for shortening and employing calculations."—*Knowledge*.

Modern Metrical Units and Systems.

MODERN METROLOGY: A Manual of the Metrical Units and Systems of the Present Century. With an Appendix containing a proposed English System. By LOWIS D'A. JACKSON, A.M.Inst.C.E., Author of "Aid to Survey Practice," &c. Large crown 8vo, 12s. 6d. cloth.

"We recommend the work to all interested in the practical reform of our weights and measures."—*Nature*.

The Metric System and the British Standards.

A SERIES OF METRIC TABLES, in which the British Standard Measures and Weights are compared with those of the Metric System at present in Use on the Continent. By C. H. DOWLING, C.E. 8vo, 10s. 6d. strongly bound.

"Mr. Dowling's Tables are well put together as a ready-reckoner for the conversion of one system into the other."—*Athenæum*.

Iron and Metal Trades' Calculator.

THE IRON AND METAL TRADES' COMPANION. For expeditiously ascertaining the Value of any Goods bought or sold by Weight, from 1s. per cwt. to 112s. per cwt., and from one farthing per pound to one shilling per pound. By THOMAS DOWNIE. Strongly bound in leather, 396 pp., 9s.

"A most useful set of tables; nothing like them before existed."—*Building News*.

"Although specially adapted to the iron and metal trades, the tables will be found useful in every other business in which merchandise is bought and sold by weight."—*Railway News*.

Calculator for Numbers and Weights Combined.

THE NUMBER, WEIGHT, AND FRACTIONAL CALCULATOR. Containing upwards of 250,000 Separate Calculations, showing at a glance the value at 422 different rates, ranging from $\frac{1}{16}$ th of a Penny to 20s. each, or per cwt., and £20 per ton, of any number of articles consecutively, from 1 to 470.—Any number of cwts., qrs., and lbs., from 1 cwt. to 470 cwts.—Any number of tons, cwts., qrs., and lbs., from 1 to 1,000 tons. By WILLIAM CHADWICK, Public Accountant. Third Edition, Revised and Improved. 8vo, price 18s., strongly bound for Office wear and tear.

Is adapted for the use of Accountants and Auditors, Railway Companies, Canal Companies, Shippers, Shipping Agents, General Carriers, etc. Ironfounders, Brassfounders, Metal Merchants, Iron Manufacturers, Ironmongers, Engineers, Machinists, Boiler Makers, Millwrights, Roofing, Bridge and Girder Makers, Colliery Proprietors, etc. Timber Merchants, Builders, Contractors, Architects, Surveyors, Auctioneers, Valuers, Brokers, Mill Owners and Manufacturers, Mill Furnishers, Merchants, and General Wholesale Tradesmen. Also for the Apportionment of Mileage Charges for Railway Traffic.

**** OPINIONS OF THE PRESS.**

"It is easy of reference for any answer or any number of answers as a dictionary, and the references are even more quickly made. For making up accounts or estimates the book must prove invaluable to all who have any considerable quantity of calculations involving price and measure in any combination to do."—*Engineer*.

"The most complete and practical ready reckoner which it has been our fortune yet to see. It is difficult to imagine a trade or occupation in which it could not be of the greatest use, either in saving human labour or in checking work. The publishers have placed within the reach of every commercial man an invaluable and unfailing assistant."—*The Miller*.

Harben's Comprehensive Weight Calculator.

THE WEIGHT CALCULATOR. Being a Series of Tables

- upon a New and Comprehensive Plan, exhibiting at One Reference the exact Value of any Weight from 1 lb. to 15 tons, at 300 Progressive Rates, from 1d. to 168s. per cwt., and containing 186,000 Direct Answers, which, with their Combinations, consisting of a single addition (mostly to be performed at sight), will afford an aggregate of 10,266,000 Answers; the whole being calculated and designed to ensure correctness and promote despatch. By HENRY HARBEN, Accountant. Fourth Edition, carefully Corrected. Royal 8vo, £1 5s., strongly half-bound.

"A practical and useful work of reference for men of business generally; it is the best of the kind we have seen."—*Ironmonger*.

"Of priceless value to business men. It is a necessary book in all mercantile offices."—*Sheffield Independent*.

Harben's Comprehensive Discount Guide.

THE DISCOUNT GUIDE. Comprising several Series of Tables for the use of Merchants, Manufacturers, Ironmongers, and others, by which may be ascertained the exact Profit arising from any mode of using Discounts, either in the Purchase or Sale of Goods, and the method of either Altering a Rate of Discount or Advancing a Price, so as to produce, by one operation, a sum that will realise any required profit after allowing one or more Discounts: to which are added Tables of Profit or Advance from $\frac{1}{4}$ to 50 per cent., Tables of Discount from $\frac{1}{4}$ to 98 $\frac{1}{2}$ per cent., and Tables of Commission, &c., from $\frac{1}{4}$ to 10 per cent. By HENRY HARBEN, Accountant, Author of "The Weight Calculator." New Edition, carefully Revised and Corrected. Demy 8vo, 544 pp., £1 5s. half-bound.

"A book such as this can only be appreciated by business men, to whom the saving of time means saving of money. We have the high authority of Professor J. R. Young that the tables throughout the work are constructed upon strictly accurate principles. The work is a model of typographical clearness, and must prove of great value to merchants, manufacturers, and general traders."—*British Trade Journal*.

Iron Shipbuilders' and Merchants' Weight Tables.

IRON-PLATE WEIGHT TABLES: For Iron Shipbuilders, Engineers, and Iron Merchants. Containing the Calculated Weights of upwards of 150,000 different sizes of Iron Plates, from 1 foot by 6 in. by $\frac{1}{4}$ in. to 10 feet by 5 feet by 1 in. Worked out on the basis of 40 lbs. to the square foot of Iron of 1 inch in thickness. Carefully compiled and thoroughly Revised by H. BURLINSON and W. H. SIMPSON. Oblong 4to, 25s. half-bound.

"This work will be found of great utility. The authors have had much practical experience of what is wanting in making estimates; and the use of the book will save much time in making elaborate calculations."—*English Mechanic*.

AGRICULTURE, FARMING, GARDENING, etc.

"The Standard Treatise on Agriculture."

THE COMPLETE GRAZIER, and FARMER'S and CATTLE-BREEDER'S ASSISTANT: A Compendium of Husbandry. Originally Written by WILLIAM YOUTT. Thirteenth Edition, entirely Re-written, considerably Enlarged, and brought up to the Present Requirements of Agricultural Practice, by WILLIAM FREEM, LL.D., Steven Lecturer in the University of Edinburgh, Author of "The Elements of Agriculture," &c. Royal 8vo, 1,100 pp., with over 450 Illustrations. Price £1 11s. 6d. strongly and handsomely bound. [Just published.]

EXTRACT FROM PUBLISHERS' ADVERTISEMENT.

"A treatise that made its original appearance in the first decade of the century, and that enters upon its Thirteenth Edition before the century has run its course, has undoubtedly established its position as a work of permanent value. It has been deemed expedient, therefore, to retain, as far as possible, in the present edition those features of Youtt's Work which must have commended themselves to general approval.

"The phenomenal progress of the last dozen years in the Practice and Science of Farming has rendered it necessary, however, that the volume should be re-written, and the publishers were fortunate enough to secure for the revision the services of Dr. FREEM, whose high attainments in all matters pertaining to agriculture have been so emphatically recognised by the highest professional and official authorities. In carrying out his editorial duties, Dr. FREEM has been favoured with valuable contributions by Prof. J. WORTLEY AXE, Mr. E. BROWN, Dr. BERNARD DYER, Mr. W. J. MALDEN, Mr. R. H. REW, Prof. SHELTON, Mr. J. SINCLAIR, Mr. SANDERS SPENCER, and others.

"No pains have been spared to make the illustrations as representative and characteristic as possible; those of Live Stock (with one or two exceptions) being new to the work; and amongst them will be found portraits of prize-winning animals of the leading breeds."

"On the whole, it may be safely said that no effort has been lacking on the part of either Editor or Publishers to make this New Edition of THE COMPLETE GRAZIER a faithful mirror of agricultural progress and a reliable record of modern practice in farming, and, as such, deserving of the reputation gained by the work (*vide Mark Lane Express*) as 'a treatise which will remain a standard work on the subject as long as British agriculture endures.'"

SUMMARY OF CONTENTS.

BOOK I. ON THE VARIETIES, BREEDING, REARING, FATTENING, AND GENERAL MANAGEMENT OF CATTLE.

BOOK II. ON THE ECONOMY AND MANAGEMENT OF THE DAIRY.

BOOK III. ON THE BREEDING, REARING, AND MANAGEMENT OF HORSES.

BOOK IV. ON THE BREEDING, REARING, AND FATTENING OF SHEEP.

BOOK V. ON THE BREEDING, REARING, AND FATTENING OF SWINE.

BOOK VI. ON THE DISEASES OF LIVE STOCK.

BOOK VII. ON THE BREEDING, REARING, AND MANAGEMENT OF POULTRY.

BOOK VIII. ON FARM OFFICES AND IMPLEMENTS OF HUSBANDRY.

BOOK IX. ON THE CULTURE AND MANAGEMENT OF GRASS LANDS.

BOOK X. ON THE CULTIVATION AND APPLICATION OF GRASSES, PULSE, AND ROOTS.

BOOK XI. ON MANURES AND THEIR APPLICATION.

BOOK XII. MONTHLY CALENDARS OF FARMWORK THROUGHOUT THE YEAR.

** OPINIONS OF THE PRESS ON PREVIOUS EDITIONS.

"The standard text-book with the farmer and grazier."—*Farmer's Magazine*.

"A treatise which will remain a standard work on the subject as long as British agriculture endures."—*Mark Lane Express* (first notice).

"The book deals with all departments of agriculture, and contains an immense amount of valuable information. It is, in fact, an encyclopædia of agriculture put into readable form, and it is the only work, equally comprehensive brought down to present date. It deserves a place in the library of every agriculturist."—*Mark Lane Express* (second notice).

British Farm Live Stock.

FARM LIVE STOCK OF GREAT BRITAIN. By ROBERT WALLACE, F.L.S., F.R.S.E., &c., Professor of Agriculture and Rural Economy in the University of Edinburgh. Third Edition, thoroughly Revised and considerably Enlarged. With over 120 Phototypes of Stock. Demy 8vo, 384 pp., with 79 Plates and Maps, price 12s. 6d. cloth. [Just published.]

"A valuable, if not an indispensable, addition to every agricultural library worthy of the name, and an excellent gift-book to all who are, or are likely to become, concerned in the care and management of live stock in any position."—*Agricultural Economist*.

"Few country gentlemen who take up this book will care to put it down again until they have looked at its hundred phototypes of prize cattle, sheep, pigs, and horses—the very best collection we have ever seen."—*Saturday Review*.

Dairy Farming.

BRITISH DAIRYING. A Handy Volume on the Work of the Dairy-Farm. For the Use of Technical Instruction Classes, Students in Agricultural Colleges, and the Working Dairy-Farmer. By Prof. J. P. SHELTON, late Special Commissioner of the Canadian Government, Author of "Dairy Farming," "The Farm and the Dairy," &c. With numerous Illustrations. Crown 8vo, 2s. 6d. cloth. [just published.]

Agricultural Facts and Figures.

NOTE-BOOK OF AGRICULTURAL FACTS AND FIGURES FOR FARMERS AND FARM STUDENTS. By PRIMROSE MCCONNELL, B.Sc., Fellow of the Highland and Agricultural Society. Fourth Edition. Royal same, roan, gilt edges, with band, 4s.

"Liberally teeming with information, and we can cordially recommend it to all connected with agriculture."—*North British Agriculturist*.

Small Farming.

SYSTEMATIC SMALL FARMING; or, The Lessons of my Farm. Being an Introduction to Modern Farm Practice for Small Farmers. By ROBERT SCOTT BURN, Author of "Outlines of Modern Farming," &c. With numerous Illustrations, crown 8vo, 6s. cloth.

"This is the completest book of its class we have seen, and one which every amateur farmer will read with pleasure and accept as a guide."—*Field*.

"The volume contains a vast amount of useful information. No branch of farming is left untouched, from the labour to be done to the results achieved. It may be safely recommended to all who think they will be in paradise when they buy or rent a three-acre farm."—*Glasgow Herald*.

Modern Farming.

OUTLINES OF MODERN FARMING. By R. SCOTT BURN. Soils, Manures, and Crops—Farming and Farming Economy—Cattle, Sheep, and Horses—Management of Dairy, Pigs, and Poultry—Utilisation of Town-Sewage, Irrigation, &c. Sixth Edition. In One Vol., 1,250 pp., half-bound, profusely Illustrated, 12s.

"The aim of the author has been to make his work at once comprehensive and trustworthy, and in this aim he has succeeded to a degree which entitles him to much credit."—*Morning Advertiser*. "No farmer should be without this book."—*Banbury Guardian*.

Agricultural Engineering.

FARM ENGINEERING, THE COMPLETE TEXT-BOOK OF. Comprising Draining and Embanking; Irrigation and Water Supply; Farm Roads, Fences, and Gates; Farm Buildings, their Arrangement and Construction, with Plans and Estimates; Barn Implements and Machines; Field Implements and Machines; Agricultural Surveying, Levelling, &c. By Prof. JOHN SCOTT, late Professor of Agriculture and Rural Economy at the Royal Agricultural College, Cirencester, &c. &c. In One Vol., 1,150 pages, half-bound, with over 600 Illustrations, 12s.

"Written with great care, as well as with knowledge and ability. The author has done his work well; we have found him a very trustworthy guide wherever we have tested his statements. The volume will be of great value to agricultural students."—*Mark Lane Express*.

"For a young agriculturist we know of no handy volume likely to be more usefully studied."—*Bell's Weekly Messenger*.

Agricultural Text-Book.

THE FIELDS OF GREAT BRITAIN: A Text-Book of Agriculture, adapted to the Syllabus of the Science and Art Department. For Elementary and Advanced Students. By HUGH CLEMENTS (Board of Trade). Second Edition, Revised, with Additions. 18mo, 2s. 6d. cloth.

"A most comprehensive volume, giving a mass of information."—*Agricultural Economist*.

"It is a long time since we have seen a book which has pleased us more, or which contains such a vast and useful fund of knowledge."—*Educational Times*.

Tables for Farmers, etc.

TABLES, MEMORANDA, AND CALCULATED RESULTS for Farmers, Graziers, Agricultural Students, Surveyors, Land Agents, Auctioneers, etc. Selected and Arranged by SIDNEY FRANCIS. Second Edition, Revised. 272 pp., waistcoat-pocket size, 1s. 6d. limp leather.

"Weighing less than 1 oz., and occupying no more space than a match box, it contains a mass of facts and calculations which has never before, in such handy form, been obtainable. We cordially recommend it."—*Bell's Weekly Messenger*.

The Management of Bees.

BEES FOR PLEASURE AND PROFIT: A Guide to the Manipulation of Bees, the Production of Honey, and the General Management of the Apiary. By G. GORDON SAMSON. With numerous Illustrations. Crown 8vo, 1s. cloth.

"The intending bee-keeper will find exactly the kind of information required to enable him to make a successful start with his hives. The author is a thoroughly competent teacher, and his book may be commended."—*Morning Post*.

Farm and Estate Book-keeping.

BOOK-KEEPING FOR FARMERS & ESTATE OWNERS.

A Practical Treatise, presenting, in Three Plans, a System adapted for all Classes of Farms. By JOHNSON M. WOODMAN, Chartered Accountant. Second Edition, Revised. Cr. 8vo, 3s. 6d. cl. bds.; or 2s. 6d. cl. limp.

"The volume is a capital study of a most important subject."—*Agricultural Gazette*.

Farm Account Book.

WOODMAN'S YEARLY FARM ACCOUNT BOOK. Giving a Weekly Labour Account and Diary, and showing the Income and Expenditure under each Department of Crops, Live Stock, Dairy, &c. &c. With Valuation, Profit and Loss Account, and Balance Sheet at the end of the Year. By JOHNSON M. WOODMAN, Chartered Accountant, Author of Book-keeping for Farmers." Folio, 7s. 6d. half-bound.

"Contains every requisite form for keeping farm accounts readily and accurately."—*Agri-culture*.

Early Fruits, Flowers, and Vegetables.

THE FORCING GARDEN; or, How to Grow Early Fruits, Flowers, and Vegetables. With Plans and Estimates for Building Glass-houses, Pits, and Frames. With Illustrations. By SAMUEL WOOD. Crown 8vo, 3s. 6d. cloth.

"A good book, and fairly fills a place that was in some degree vacant." The book is written with great care, and contains a great deal of valuable teaching."—*Gardeners' Magazine*.

Good Gardening.

A PLAIN GUIDE TO GOOD GARDENING; or, How to Grow Vegetables, Fruits, and Flowers. By S. WOOD. Fourth Edition, with considerable Additions, &c., and numerous Illustrations. Crown 8vo, 3s. 6d. cl.

"May be recommended to young gardeners, cottagers, and specially to amateurs, for the plain, simple, and trustworthy information it gives on common matters too often neglected."—*Gardeners' Chronicle*.

Gainful Gardening.

MULTUM-IN-PARVO GARDENING; or, How to make One Acre of Land produce £600 a-year by the Cultivation of Fruits and Vegetables; also, How to Grow Flowers in Three Glass Houses, so as to realise £176 per annum clear Profit. By SAMUEL WOOD, Author of "Good Gardening," &c. Fifth and Cheaper Edition, Revised, with Additions. Crown 8vo, 1s. sewed.

"We are bound to recommend it as not only suited to the case of the amateur and gentleman's gardener, but to the market grower."—*Gardeners' Magazine*.

Gardening for Ladies.

THE LADIES' MULTUM-IN-PARVO FLOWER GARDEN, and Amateurs' Complete Guide. With Illusts. By S. WOOD. Cr. 8vo, 3s. 6d. cl.

"This volume contains a good deal of sound, common sense instruction."—*Florist*.

"Full of shrewd hints and useful instructions, based on a lifetime of experience."—*Scotsman*.

Receipts for Gardeners.

GARDEN RECEIPTS. Edited by CHARLES W. QUIN. 12mo, 1s. 6d. cloth limp.

"A useful and handy book, containing a good deal of valuable information."—*Athenaeum*.

Market Gardening.

MARKET AND KITCHEN GARDENING. By Contributors to "The Garden." Compiled by C. W. SHAW, late Editor of "Gardening Illustrated." 12mo, 3s. 6d. cloth boards.

"The most valuable compendium of kitchen and market-garden work published."—*Farmer*.

Cottage Gardening.

COTTAGE GARDENING; or, Flowers, Fruits, and Vegetables for Small Gardens. By E. HOBDAY. 12mo, 1s. 6d. cloth limp.

"Contains much useful information at a small charge."—*Glasgow Herald*.

AUCTIONEERING, VALUING, LAND SURVEYING ESTATE AGENCY, etc.

Auctioneer's Assistant.

THE APPRAISER, AUCTIONEER, BROKER, HOUSE AND ESTATE AGENT AND VALUER'S POCKET ASSISTANT, for the Valuation for Purchase, Sale, or Renewal of Leases, Annuities and Reversions, and of property generally; with Prices for Inventories, &c. By JOHN WHEELER, Valuer, &c. Sixth Edition, Re-written and greatly extended by C. NORRIS, Surveyor, Valuer, &c. Royal 32mo, 5s. cloth.

"A neat and concise book of reference, containing an admirable and clearly-arranged list of prices for inventories, and a very practical guide to determine the value of furniture, &c."—*Standard*.

"Contains a large quantity of varied and useful information as to the valuation for purchase, sale, or renewal of leases, annuities and reversions, and of property generally, with prices for inventories, and a guide to determine the value of interior fittings and other effects."—*Bidder*.

Auctioneering.

AUCTIONEERS: THEIR DUTIES AND LIABILITIES.

A Manual of Instruction and Counsel for the Young Auctioneer. By ROBERT SQUIBB, Auctioneer. Second Edition, Revised and partly Re-written. Demy 8vo, 12s. 6d. cloth.

"The standard text-book on the topics of which it treats."—*Athenaeum*.

"The work is one of general excellent character, and gives much information in a compendious and satisfactory form."—*Bidder*.

"May be recommended as giving a great deal of information on the law relating to auctioneers, in a very readable form."—*Law Journal*.

"Auctioneers may be congratulated on having so pleasing a writer to minister to their special needs."—*Solicitors' Journal*.

Inwood's Estate Tables.

TABLES FOR THE PURCHASING OF ESTATES, Freehold, Copyhold, or Leasehold; Annuities, Advowsons, &c., and for the Renewing of Leases held under Cathedral Churches, Colleges, or other Corporate bodies, for Terms of Years certain, and for Lives; also for Valuing Reversionary Estates, Deferred Annuities, Next Presentations, &c.; together with SMART'S Five Tables of Compound Interest, and an Extension of the same to Lower and Intermediate Rates. By W. INWOOD. 23rd Edition, with considerable Additions, and new and valuable Tables of Logarithms for the more Difficult Computations of the Interest of Money, Discount, Annuities, &c., by M. FÉDOR THOMAN, of the Société Crédit Mobilier of Paris. Crown 8vo, 8s. cloth.

"Those interested in the purchase and sale of estates, and in the adjustment of compensation cases, as well as in transactions in annuities, life insurances, &c., will find the present edition of eminent service."—*Engineering*.

Agricultural Valuer's Assistant.

THE AGRICULTURAL VALUER'S ASSISTANT. A Practical Handbook on the Valuation of Landed Estates; including Rules and Data for Measuring and Estimating the Contents, Weights, and Values of Agricultural Produce and Timber, and the Values of Feeding Stuffs, Manures, and Labour; with Forms of Tenant-Right-Valuations, Lists of Local Agricultural Customs, Scales of Compensation under the Agricultural Holdings Act, &c. &c. By TOM BRIGHT, Agricultural Surveyor. Second Edition, much Enlarged. Crown 8vo, 5s. cloth. [Just published.]

"Full of tables and examples in connection with the valuation of tenant-right, estates, labour, contents, and weights of timber, and farm produce of all kinds."—*Agricultural Gazette*.

"An eminently practical handbook, full of practical tables and data of undoubted interest and value to surveyors and auctioneers in preparing valuations of all kinds."—*Farmer*.

Plantations and Underwoods.

POLE PLANTATIONS AND UNDERWOODS: A Practical Handbook on Estimating the Cost of Forming, Renovating, Improving, and Grubbing Plantations and Underwoods, their Valuation for Purposes of Transfer, Rental, Sale, or Assessment. By TOM BRIGHT, Author of "The Agricultural Valuer's Assistant," &c. Crown 8vo, 5s. 6d. cloth.

"To valuers, foresters and agents it will be a welcome aid."—*North British Agriculturist*.

"Well calculated to assist the valuer in the discharge of his duties, and of undoubted interest and use both to surveyors and auctioneers in preparing valuations of all kinds."—*Kent Herald*.

Hudson's Land Valuer's Pocket-Book.

THE LAND VALUER'S BEST ASSISTANT: Being Tables on a very much Improved Plan, for Calculating the Value of Estates. With Tables for reducing Scotch, Irish, and Provincial Customary Acres to Statute Measure, &c. By R. HUDSON, C.E. New Edition. Royal 32mo, leather, elastic band, 4s.

Ewart's Land Improver's Pocket-Book.

THE LAND IMPROVER'S POCKET-BOOK OF FORMULÆ, TABLES, and MEMORANDA required in any Computation relating to the Permanent Improvement of Landed Property. By JOHN EWART, Land Surveyor and Agricultural Engineer. Second Edition, Revised. Royal 32mo, oblong, leather, gilt edges, with elastic band, 4s.

"A compendious and handy little volume."—*Spectator*.

Complete Agricultural Surveyor's Pocket-Book.

THE LAND VALUER'S AND LAND IMPROVER'S COMPLETE POCKET-BOOK. Consisting of the above Two Works bound together. Leather, gilt edges, with strap, 7s. 6d.

House Property.

HANDBOOK OF HOUSE PROPERTY. A Popular and Practical Guide to the Purchase, Mortgage, Tenancy, and Compulsory Sale of Houses and Land, including the Law of Dilapidations and Fixtures; with Examples of all kinds of Valuations, Useful Information on Building, and Suggestive Elucidations of Fine Art. By E. L. TARBUCK, Architect and Surveyor. Fifth Edition, Enlarged. 12mo, 5s. cloth.

"The advice is thoroughly practical."—*Law Journal*.

"For all who have dealings with house property, this is an indispensable guide."—*Decoration*.

"Carefully brought up to date, and much improved by the addition of a division on fine art. . . . A well-written and thoughtful work."—*Land Agent's Record*.

LAW AND MISCELLANEOUS.

Private Bill Legislation and Provisional Orders.

HANDBOOK FOR THE USE OF SOLICITORS AND ENGINEERS Engaged in Promoting Private Acts of Parliament and Provisional Orders, for the Authorization of Railways, Tramways, Works for the Supply of Gas and Water, and other undertakings of a like character. By L. LIVINGSTON MACASKEY, of the Middle Temple, Barrister-at-Law, M. Inst. C.E.; Author of "Hints on Water Supply." Demy 8vo, 950 pp., 25s. cl.

"The author's double experience as an engineer and barrister has enabled him to approach the subject alike from an engineering and legal point of view."—*Local Government Chronicle*.

Law of Patents.

PATENTS FOR INVENTIONS, AND HOW TO PROCURE THEM. Compiled for the Use of Inventors, Patentees and others. By G. G. M. HARDINGHAM, Assoc. Mem. Inst. C.E., &c. Demy 8vo, 2s. 6d. cloth.

Metropolitan Rating Appeals.

REPORTS OF APPEALS HEARD BEFORE THE COURT OF GENERAL ASSESSMENT SESSIONS, from the Year 1871 to 1883. By EDWARD RYDE and ARTHUR LYON RYDE. Fourth Edition, with Introduction and Appendix by WALTER C. RYDE, of the Inner Temple, Barrister-at-Law. 8vo, 16s. cloth.

Pocket-Book for Sanitary Officials.

THE HEALTH OFFICER'S POCKET-BOOK: A Guide to Sanitary Practice and Law. For Medical Officers of Health, Sanitary Inspectors, Members of Sanitary Authorities, &c. By EDWARD F. WILLOUGHBY, M.D. (Lond.), &c., Author of "Hygiene and Public Health." Fcap. 8vo, 7s. 6d. cloth, red edges, rounded corners. [Just published.]

"A mine of condensed information of a pertinent and useful kind on the various subjects of which it treats. The matter seems to have been carefully compiled and arranged for facility of reference, and it is well illustrated by diagrams and woodcuts. The different subjects are succinctly but fully and scientifically dealt with."—*The Lancet*.

A Complete Epitome of the Laws of this Country.

EVERY MAN'S OWN LAWYER: A Handy-Book of the Principles of Law and Equity. By A BARRISTER. Thirtieth Edition, carefully Revised, and including the Legislation of 1892. Comprising (amongst other Acts) the *Betting and Loans (Infants) Act, 1892*; the *Small Holdings Act, 1892*; the *Clergy Discipline Act, 1892*; the *Conveyancing and Law of Property Act, 1892*, &c.; as well as the *Forged Transfers Act, 1891*; the *Custody of Children Act, 1891*; the *Slander of Women Act, 1891*; the *Bankruptcy Act, 1890*; the *Directors' Liability Act, 1890*; the *Partnership Act, 1890*; the *Intestates' Estates Act, 1890*, and many other new Acts. Crown 8vo, 700 pp., price 6s. 6d. (saved at every consultation!), strongly bound in cloth.

[Just published.

. The Book will be found to comprise (amongst other matter)—

THE RIGHTS AND WRONGS OF INDIVIDUALS—LANDLORD AND TENANT—VENDORS AND PURCHASERS—PARTNERS AND AGENTS—COMPANIES AND ASSOCIATIONS—MASTERS, SERVANTS, AND WORKMEN—LEASES AND MORTGAGES—CHURCH AND CLERGY, RITUAL—LIBEL AND SLANDER—CONTRACTS AND AGREEMENTS—BONDS AND BILLS OF SALE—CHEQUES, BILLS, AND NOTES—RAILWAY AND SHIPPING LAW—BANKRUPTCY AND INSURANCE—BORROWERS, LENDERS, AND SURETIES—CRIMINAL LAW—PARLIAMENTARY ELECTIONS—COUNTY COUNCILS—MUNICIPAL CORPORATIONS—PARISH LAW, CHURCHWARDENS, &c.—INSANITARY DWELLINGS AND AREAS—PUBLIC HEALTH AND NUISANCES—FRIENDLY AND BUILDING SOCIETIES—COPYRIGHT AND PATENTS—TRADE MARKS AND DESIGNS—HUSBAND AND WIFE, DIVORCE, &c.—TRUSTEES AND EXECUTORS—GUARDIAN AND WARD, INFANTS, &c.—GAME LAWS AND SPORTING—HORSES, HORSE-DEALING, AND DOGS—INNKEEPERS, LICENSING, &c.—FORMS OF WILLS, AGREEMENTS, &c. &c.

☞ The object of this work is to enable those who consult it to help themselves to the law; and thereby to dispense, as far as possible, with professional assistance and advice. There are many wrongs and grievances which persons submit to from time to time through not knowing how or where to apply for redress; and many persons have as great a dread of a lawyer's office as of a lion's den. With this book at hand it is believed that many a SIX-AND-EIGHTPENCE may be saved; many a wrong redressed; many a right reclaimed; many a law suit avoided; and many an evil abated. The work has established itself as the standard legal adviser of all classes, and has also made a reputation for itself as a useful book of reference for lawyers residing at a distance from law libraries, who are glad to have at hand a work embodying recent decisions and enactments.

***.* OPINIONS OF THE PRESS.**

"It is a complete code of English Law, written in plain language, which all can understand. Should be in the hands of every business man, and all who wish to abolish lawyers' bills."—*Weekly Times*.

"A useful and concise epitome of the law, compiled with considerable care."—*Law Magazine*

"A complete digest of the most useful facts which constitute English law."—*Globe*.

"This excellent handbook. . . . Admirably done, admirably arranged, and admirably cheap."—*Leeds Mercury*.

"A concise, cheap and complete epitome of the English law. So plainly written that he who runs may read, and he who reads may understand."—*Figure*.

"A dictionary of legal facts well put together. The book is a very useful one."—*Spectator*.

"A work which has long been wanted, which is thoroughly well done, and which we most cordially recommend."—*Sunday Times*.

"The latest edition of this popular book ought to be in every business establishment, and on every library table."—*Sheffield Post*.

"A complete epitome of the law; thoroughly intelligible to non-professional readers."

Bell's Life.

Legal Guide for Pawnbrokers.

THE PAWNBROKERS', FACTORS' AND MERCHANTS' GUIDE TO THE LAW OF LOANS AND PLEDGES. With the Statutes and a Digest of Cases on Rights and Liabilities, Civil and Criminal, as to Loans and Pledges of Goods, Debentures, Mercantile and other Securities. By H. C. FOLKARD, Esq., Barrister-at-Law, Author of "The Law of Slander and Libel," &c. With Additions and Corrections. Fcap. 8vo, 32. 6d. cloth.

"This work contains simply everything that requires to be known concerning the department of the law of which it treats. We can safely commend the book as unique and very nearly perfect."—*Iron*.

The Law of Contracts.

LABOUR CONTRACTS: A Popular Handbook on the Law of Contracts for Works and Services. By DAVID GIBBONS. Fourth Edition, with Appendix of Statutes by T. F. UTTLEY, Solicitor. Fcap. 8vo, 3s. 6d. cloth. [Just published.

ODGEN, SMALE AND CO. LIMITED, PRINTERS, GREAT SAFFRON HILL, E.C.

Weale's Rudimentary Series.



LONDON, 1862.

THE PRIZE MEDAL

Was awarded to the Publishers of

"WEALE'S SERIES."



A NEW LIST OF

WEALE'S SERIES

RUDIMENTARY SCIENTIFIC, EDUCATIONAL,
AND CLASSICAL.

Comprising nearly Three Hundred and Fifty distinct works in almost every department of Science, Art, and Education, recommended to the notice of Engineers, Architects, Builders, Artisans, and Students generally, as well as to those interested in Workmen's Libraries, Literary and Scientific Institutions, Colleges, Schools, Science Classes, &c., &c.

“WEALE'S SERIES includes Text-Books on almost every branch of Science and Industry, comprising such subjects as Agriculture, Architecture and Building, Civil Engineering, Fine Arts, Mechanics and Mechanical Engineering, Physical and Chemical Science, and many miscellaneous Treatises. The whole are constantly undergoing revision, and new editions, brought up to the latest discoveries in scientific research, are constantly issued. The prices at which they are sold are as low as their excellence is assured.”—*American Literary Gazette*.

“Amongst the literature of technical education, WEALE'S SERIES has ever enjoyed a high reputation, and the additions being made by Messrs. CROSBY LOCKWOOD & SON render the series more complete, and bring the information upon the several subjects down to the present time.”—*Mining Journal*.

“It is not too much to say that no books have ever proved more popular with, or more useful to, young engineers and others than the excellent treatises comprised in WEALE'S SERIES.”—*Engineer*.

“The excellence of WEALE'S SERIES is now so well appreciated, that it would be wasting our space to enlarge upon their general usefulness and value.”—*Builder*.

“The volumes of WEALE'S SERIES form one of the best collections of elementary technical books in any language.”—*Architect*.

“WEALE'S SERIES has become a standard as well as an unrivalled collection of treatises in all branches of art and science.”—*Public Opinion*.



PHILADELPHIA, 1876.
THE PRIZE MEDAL

Was awarded to the Publishers for
Books: Rudimentary, Scientific,
“WEALE'S SERIES,” ETC.



CROSBY LOCKWOOD & SON,

7, STATIONERS' HALL COURT, LUDGATE HILL, LONDON, E.C.

WEALE'S RUDIMENTARY SCIENTIFIC SERIES.



. The volumes of this Series are freely Illustrated with Woodcuts, or otherwise, where requisite. Throughout the following List it must be understood that the books are bound in limp cloth, unless otherwise stated; *but the volumes marked with a ‡ may also be had strongly bound in cloth boards for 6d. extra.*

N.B.—In ordering from this List it is recommended, as a means of facilitating business and obviating error, to quote the numbers affixed to the volumes, as well as the titles and prices.

CIVIL ENGINEERING, SURVEYING, ETC.

- No.
31. **WELLS AND WELL-SINKING.** By JOHN GEO. SWINDELL, A.R.I.B.A., and G. R. BURNELL, C.E. Revised Edition. With a New Appendix on the Qualities of Water. Illustrated. 2s.
 35. **THE BLASTING AND QUARRYING OF STONE,** for Building and other Purposes. By Gen. Sir J. BURGOYNE, Bart. 1s. 6d.
 43. **TUBULAR, AND OTHER IRON GIRDER BRIDGES,** particularly describing the Britannia and Conway Tubular Bridges. By G. DRYSDALE DEMPSEY, C.E. Fourth Edition. 2s.
 44. **FOUNDATIONS AND CONCRETE WORKS,** with Practical Remarks on Footings, Sand, Concrete, Béton, Pile-driving, Caissons, and Cofferdams, &c. By E. DOBSON. Seventh Edition. 1s. 6d.
 60. **LAND AND ENGINEERING SURVEYING.** By T. BAKER, C.E. Fifteenth Edition, revised by Professor J. R. YOUNG. 2s.‡
 - 80*. **EMBANKING LANDS FROM THE SEA.** With examples and Particulars of actual Embankments, &c. By J. WIGGINS, F.G.S. 2s.
 81. **WATER WORKS,** for the Supply of Cities and Towns. With a Description of the Principal Geological Formations of England as influencing Supplies of Water, &c. By S. HUGHES, C.E. New Edition. 4s.‡
 118. **CIVIL ENGINEERING IN NORTH AMERICA,** a Sketch of. By DAVID STEVENSON, F.R.S.E., &c. Plates and Diagrams. 3s.
 167. **IRON BRIDGES, GIRDERS, ROOFS, AND OTHER WORKS.** By FRANCIS CAMPIN, C.E. 2s. 6d.‡
 197. **ROADS AND STREETS.** By H. LAW, C.E., revised and enlarged by D. K. CLARK, C.E., including pavements of Stone, Wood, Asphalte, &c. 4s. 6d.‡
 203. **SANITARY WORK IN THE SMALLER TOWNS AND IN VILLAGES.** By C. SLAGG, A.M.I.C.E. Revised Edition. 3s.‡
 212. **GAS-WORKS, THEIR CONSTRUCTION AND ARRANGEMENT;** and the Manufacture and Distribution of Coal Gas. Originally written by SAMUEL HUGHES, C.E. Re-written and enlarged by WILLIAM RICHARDS, C.E. Eighth Edition, with important additions. 5s. 6d.‡
 213. **PIONEER ENGINEERING.** A Treatise on the Engineering Operations connected with the Settlement of Waste Lands in New Countries. By EDWARD DOBSON, Assoc. Inst. C.E. 4s. 6d.‡
 216. **MATERIALS AND CONSTRUCTION;** A Theoretical and Practical Treatise on the Strains, Designing, and Erection of Works of Construction. By FRANCIS CAMPIN, C.E. Second Edition, revised. 3s.‡
 219. **CIVIL ENGINEERING.** By HENRY LAW, M.Inst. C.E. Including HYDRAULIC ENGINEERING by GEO. R. BURNELL, M.Inst. C.E. Seventh Edition, revised, with large additions by D. KINNEAR CLARK, M.Inst. C.E. 6s. 6d., Cloth boards, 7s. 6d.
 268. **THE DRAINAGE OF LANDS, TOWNS, & BUILDINGS.** By G. D. DEMPSEY, C.E. Revised, with large Additions on Recent Practice in Drainage Engineering, by D. KINNEAR CLARK, M.I.C.E. Second Edition, Corrected. 4s. 6d.‡

⚙ The ‡ indicates that these vols. may be had strongly bound at 6d. extra.

LONDON: CROSBY LOCKWOOD AND SON,

MECHANICAL ENGINEERING, ETC.

33. *CRANES*, the Construction of, and other Machinery for Raising Heavy Bodies. By JOSEPH GLYNN, F.R.S. Illustrated. 1s. 6d.
 34. *THE STEAM ENGINE*. By Dr. LARDNER. Illustrated. 1s. 6d.
 59. *STEAM BOILERS*: their Construction and Management. By R. ARMSTRONG, C.E. Illustrated. 1s. 6d.
 82. *THE POWER OF WATER*, as applied to drive Flour Mills, and to give motion to Turbines, &c. By JOSEPH GLYNN, F.R.S. 2s. 4
 98. *PRACTICAL MECHANISM*, the Elements of; and Machine Tools. By T. BAKER, C.E. With Additions by J. NASMYTH, C.E. 2s. 6d. 4
 139. *THE STEAM ENGINE*, a Treatise on the Mathematical Theory of, with Rules and Examples for Practical Men. By T. BAKER, C.E. 1s. 6d.
 164. *MODERN WORKSHOP PRACTICE*, as applied to Steam Engines, Bridges, Ship-building, &c. By J. G. WINTON. New Edition. 3s. 6d. 4
 165. *IRON AND HEAT*, exhibiting the Principles concerned in the Construction of Iron Beams, Pillars, and Girders. By J. ARMOUR. 2s. 6d. 4
 166. *POWER IN MOTION*: Horse-Power, Toothed-Wheel Gearing, Long and Short Driving Bands, and Angular Forces. By J. ARMOUR. 2s. 4
 171. *THE WORKMAN'S MANUAL OF ENGINEERING DRAWING*. By J. MAXTON. 7th Edn. With 7 Plates and 350 Cuts. 3s. 6d. 4
 190. *STEAM AND THE STEAM ENGINE*, Stationary and Portable. By J. SEWELL and D. K. CLARK, C.E. 3s. 6d. 4
 200. *FUEL*, its Combustion and Economy. By C. W. WILLIAMS. With Recent Practice in the Combustion and Economy of Fuel—Coal, Coke, Wood, Peat, Petroleum, &c.—by D. K. CLARK, M.I.C.E. 3s. 6d. 4
 202. *LOCOMOTIVE ENGINES*. By G. D. DEMPSEY, C.E.; with large additions by D. KINNAR CLARK, M.I.C.E. 3s. 4
 211. *THE BOILERMAKER'S ASSISTANT* in Drawing, Templating, and Calculating Boiler and Tank Work. By JOHN COURTNEY, Practical Boiler Maker. Edited by D. K. CLARK, C.E. 100 Illustrations. 2s.
 217. *SEWING MACHINERY*: Its Construction, History, &c., with full Technical Directions for Adjusting, &c. By J. W. URQUHART, C.E. 2s. 4
 223. *MECHANICAL ENGINEERING*. Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Manufacture of the Steam Engine, &c. By FRANCIS CAMPIN, C.E. Second Edition. 2s. 6d. 4
 236. *DETAILS OF MACHINERY*. Comprising Instructions for the Execution of various Works in Iron. By FRANCIS CAMPIN, C.E. 3s. 4
 237. *THE SMITHY AND FORGE*; including the Farrier's Art and Coach Smithing. By W. J. E. CRANE. Illustrated. 2s. 6d. 4
 238. *THE SHEET-METAL WORKER'S GUIDE*; a Practical Handbook for Tinsmiths, Coppersmiths, Zincworkers, &c. With 94 Diagrams and Working Patterns. By W. J. E. CRANE. Second Edition, revised. 1s. 6d.
 251. *STEAM AND MACHINERY MANAGEMENT*: with Hints on Construction and Selection. By M. POWIS BALE, M.I.M.E. 2s. 6d. 4
 254. *THE BOILERMAKER'S READY-RECKONER*. By J. COURTNEY. Edited by D. K. CLARK, C.E. 4s.
- * Nos. 211 and 254 in One Vol., half-bound, entitled "THE BOILERMAKER'S READY-RECKONER AND ASSISTANT." By J. COURTNEY and D. K. CLARK. 7s.
255. *LOCOMOTIVE ENGINE-DRIVING*. A Practical Manual for Engineers in charge of Locomotive Engines. By MICHAEL REYNOLDS, M.S.E. Eighth Edition. 3s. 6d., limp; 4s. 6d. cloth boards.
 256. *STATIONARY ENGINE-DRIVING*. A Practical Manual for Engineers in charge of Stationary Engines. By MICHAEL REYNOLDS, M.S.E. Fourth Edition. 3s. 6d. limp; 4s. 6d. cloth boards.
 260. *IRON BRIDGES OF MODERATE SPAN*: their Construction and Erection. By HAMILTON W. PENDRED, C.E. 2s.

 The 4 indicates that these vols. may be had strongly bound at 6d. extra.

MINING, METALLURGY, ETC.

4. **MINERALOGY**, Rudiments of; a concise View of the General Properties of Minerals. By A. RAMSAY, F.G.S., F.R.G.S., &c. Third Edition, revised and enlarged. Illustrated. 3s. 6d.‡
117. **SUBTERRANEAN SURVEYING**, with and without the Magnetic Needle. By T. FENWICK and T. BAKER, C.E. Illustrated. 2s. 6d.‡
135. **ELECTRO-METALLURGY**; Practically Treated. By ALEXANDER WATT. Ninth Edition, enlarged and revised, with additional Illustrations, and including the most recent Processes. 3s. 6d.‡
172. **MINING TOOLS**, Manual of. For the Use of Mine Managers, Agents, Students, &c. By WILLIAM MORGANS. 2s. 6d.
- 172*. **MINING TOOLS, ATLAS** of Engravings to Illustrate the above, containing 235 Illustrations, drawn to Scale. 4to. 4s. 6d.
176. **METALLURGY OF IRON**. Containing History of Iron Manufacture, Methods of Assay, and Analyses of Iron Ores, Processes of Manufacture of Iron and Steel, &c. By H. BAUERMAN, F.G.S. Sixth Edition, revised and enlarged. 5s.‡
180. **COAL AND COAL MINING**. By the late Sir WARINGTON W. SMYTH, M.A., F.R.S. Seventh Edition, revised. 3s. 6d.‡
195. **THE MINERAL SURVEYOR AND VALUER'S COMPLETE GUIDE**. By W. LINTERN, M.E. Third Edition, including Magnetic and Angular Surveying. With Four Plates. 3s. 6d.‡
214. **SLATE AND SLATE QUARRYING**, Scientific, Practical, and Commercial. By D. C. DAVIES, F.G.S., Mining Engineer, &c. 3s.‡
264. **A FIRST BOOK OF MINING AND QUARRYING**, with the Sciences connected therewith, for Primary Schools and Self-Instruction. By J. H. COLLINS, F.G.S. Second Edition, with additions. 1s. 6d.

ARCHITECTURE, BUILDING, ETC.

16. **ARCHITECTURE—ORDERS**—The Orders and their Æsthetic Principles. By W. H. LEEDS. Illustrated. 1s. 6d.
17. **ARCHITECTURE—STYLES**—The History and Description of the Styles of Architecture of Various Countries, from the Earliest to the Present Period. By T. TALBOT BURY, F.R.I.B.A., &c. Illustrated. 2s.
* * ORDERS AND STYLES OF ARCHITECTURE, in *One Vol.*, 3s. 6d.
18. **ARCHITECTURE—DESIGN**—The Principles of Design in Architecture, as deducible from Nature and exemplified in the Works of the Greek and Gothic Architects. By E. L. GARRETT, Architect. Illustrated. 2s. 6d.
* * The three preceding Works, in *One handsome Vol.*, half bound, entitled "MODERN ARCHITECTURE," price 6s.
22. **THE ART OF BUILDING**, Rudiments of. General Principles of Construction, Materials used in Building, Strength and Use of Materials, Working Drawings, Specifications, and Estimates. By E. DOBSON, 2s.‡
25. **MASONRY AND STONECUTTING**: Rudimentary Treatise on the Principles of Masonic Projection and their application to Construction. By EDWARD DOBSON, M.R.I.B.A., &c. 2s. 6d.‡
42. **COTTAGE BUILDING**. By C. BRUCE ALLEN, Architect. Eleventh Edition, revised and enlarged. With a Chapter on Economic Cottages for Allotments, by EDWARD E. ALLEN, C.E. 2s.
45. **LIMES, CEMENTS, MORTARS, CONCRETES, MASTICS, PLASTERING**, &c. By G. R. BURNELL, C.E. Fourteenth Edition. 1s. 6d.
57. **WARMING AND VENTILATION**. An Exposition of the General Principles as applied to Domestic and Public Buildings, Mines, Lighthouses, Ships, &c. By C. TOMLINSON, F.R.S., &c. Illustrated. 3s.
111. **ARCHES, PIERS, BUTTRESSES, &c.**: Experimental Essays on the Principles of Construction. By W. BLAND. Illustrated. 1s. 6d.

‡ The ‡ indicates that these vols. may be had strongly bound at 6d. extra.

Architecture, Building, etc., continued.

116. **THE ACOUSTICS OF PUBLIC BUILDINGS**; or, The Principles of the Science of Sound applied to the purposes of the Architect and Builder. By T. ROGER SMITH, M.R.I.B.A., Architect. Illustrated. 1s. 6d.
127. **ARCHITECTURAL MODELLING IN PAPER**, the Art of. By T. A. RICHARDSON, Architect. Illustrated. 1s. 6d.
128. **VITRUVIUS—THE ARCHITECTURE OF MARCUS VITRUVIUS POLLO**. In Ten Books. Translated from the Latin by JOSEPH GWILT, F.S.A., F.R.A.S. With 23 Plates. 5s.
130. **GRECIAN ARCHITECTURE**, An Inquiry into the Principles of Beauty in; with an Historical View of the Rise and Progress of the Art in Greece. By the EARL OF ABERDEEN. 1s.
- * The two preceding Works in One handsome Vol., half bound, entitled "**ANCIENT ARCHITECTURE**," price 6s.
132. **THE ERECTION OF DWELLING-HOUSES**. Illustrated by a Perspective View, Plans, Elevations, and Sections of a pair of Semi-detached Villas, with the Specification, Quantities, and Estimates, &c. By S. H. BROOKS. New Edition, with Plates. 2s. 6d.†
156. **QUANTITIES & MEASUREMENTS** in Bricklayers', Masons', Plasterers', Plumbers', Painters', Paperhangers', Gilders', Smiths', Carpenters' and Joiners' Work. By A. C. BRATON, Surveyor. Ninth Edition. 1s. 6d.
175. **LOCKWOOD'S BUILDER'S PRICE BOOK FOR 1893**. A Comprehensive Handbook of the Latest Prices and Data for Builders, Architects, Engineers, and Contractors. Re-constructed, Re-written, and further Enlarged. By FRANCIS T. W. MILLER, A.R.I.B.A. 700 pages. 3s. 6d.; cloth boards, 4s. [Just Published.]
182. **CARPENTRY AND JOINERY—THE ELEMENTARY PRINCIPLES OF CARPENTRY**. Chiefly composed from the Standard Work of THOMAS TREDGOLD, C.E. With a TREATISE ON JOINERY by E. WYNDHAM TARN, M.A. Fifth Edition, Revised. 3s. 6d.†
- 182*. **CARPENTRY AND JOINERY. ATLAS** of 35 Plates to accompany the above. With Descriptive Letterpress. 4to. 6s.
185. **THE COMPLETE MEASURER**; the Measurement of Boards, Glass, &c.; Unequal-sided, Square-sided, Octagonal-sided, Round Timber and Stone, and Standing Timber, &c. By RICHARD HORTON. Fifth Edition. 4s.; strongly bound in leather, 5s.
187. **HINTS TO YOUNG ARCHITECTS**. By G. WIGHTWICK. New Edition. By G. H. GUILLAUME. Illustrated. 3s. 6d.†
188. **HOUSE PAINTING, GRAINING, MARBLING, AND SIGN WRITING**: with a Course of Elementary Drawing for House-Painters, Sign-Writers, &c., and a Collection of Useful Receipts. By ELLIS A. DAVIDSON. Sixth Edition. With Coloured Plates. 5s. cloth limp; 6s. cloth boards.
189. **THE RUDIMENTS OF PRACTICAL BRICKLAYING**. In Six Sections: General Principles; Arch Drawing, Cutting, and Setting; Pointing; Paving, Tiling, Materials; Slating and Plastering; Practical Geometry, Mensuration, &c. By ADAM HAMMOND. Seventh Edition. 1s. 6d.
191. **PLUMBING**. A Text-Book to the Practice of the Art or Craft of the Plumber. With Chapters upon House Drainage and Ventilation. Sixth Edition. With 380 Illustrations. By W. P. BUCHAN. 3s. 6d.†
192. **THE TIMBER IMPORTER'S, TIMBER MERCHANT'S, and BUILDER'S STANDARD GUIDE**. By R. E. GRANDY. 2s.
206. **A BOOK ON BUILDING, Civil and Ecclesiastical**, including CHURCH RESTORATION. With the Theory of Domes and the Great Pyramid, &c. By Sir EDMUND BECKETT, Bart., LL.D., Q.C., F.R.A.S. 4s. 6d.†
226. **THE JOINTS MADE AND USED BY BUILDERS** in the Construction of various kinds of Engineering and Architectural Works. By WYVILL J. CHRISTY, Architect. With upwards of 160 Engravings on Wood. 3s.†
228. **THE CONSTRUCTION OF ROOFS OF WOOD AND IRON**. By E. WYNDHAM TARN, M.A., Architect. Second Edition, revised. 1s. 6d.

† The † indicates that these vols. may be had strongly bound at 6d. extra.

Architecture, Building, etc., continued.

229. **ELEMENTARY DECORATION:** as applied to the Interior and Exterior Decoration of Dwelling-Houses, &c. By J. W. FACEY. 2s.
257. **PRACTICAL HOUSE DECORATION.** A Guide to the Art of Ornamental Painting. By JAMES W. FACEY. 2s. 6d.
- *• *The two preceding Works, in One handsome Vol., half-bound, entitled "HOUSE DECORATION, ELEMENTARY AND PRACTICAL," price 5s.*
230. **A PRACTICAL TREATISE ON HANDRAILING.** Showing New and Simple Methods. By G. COLLINGS. Second Edition, Revised, including A TREATISE ON STAIRBUILDING. Plates. 2s. 6d.
247. **BUILDING ESTATES:** a Rudimentary Treatise on the Development, Sale, Purchase, and General Management of Building Land. By FOWLER MAITLAND, Surveyor. Second Edition, revised. 2s.
248. **PORTLAND CEMENT FOR USERS.** By HENRY FAIJA, Assoc. M. Inst. C.E. Third Edition, corrected. Illustrated. 2s.
252. **BRICKWORK:** a Practical Treatise, embodying the General and Higher Principles of Bricklaying, Cutting and Setting, &c. By F. WALKER. Third Edition, Revised and Enlarged. 1s. 6d.
23. **THE PRACTICAL BRICK AND TILE BOOK.** Comprising :
 189. BRICK AND TILE MAKING, by E. DOBSON, A.I.C.E.; PRACTICAL BRICKLAYING, by A. HAMMOND; BRICKCUTTING AND SETTING, by A. HAMMOND. 534 pp. with 270 Illustrations. 6s. Strongly half-bound.
253. **THE TIMBER MERCHANT'S, SAW-MILLER'S, AND IMPORTER'S FREIGHT-BOOK AND ASSISTANT.** By WM. RICHARDSON. With Additions by M. POWIS BALE, A.M.Inst.C.E. 3s. 1/2
258. **CIRCULAR WORK IN CARPENTRY AND JOINERY.** A Practical Treatise on Circular Work of Single and Double Curvature. By GEORGE COLLINGS. Second Edition, 2s. 6d.
259. **GAS FITTING:** A Practical Handbook treating of every Description of Gas Laying and Fitting. By JOHN BLACK. 2s. 6d. 1/2
261. **SHORING AND ITS APPLICATION:** A Handbook for the Use of Students. By GEORGE H. BLAGROVE. 1s. 6d.
265. **THE ART OF PRACTICAL BRICKCUTTING & SETTING.** By ADAM HAMMOND. With 90 Engravings. 1s. 6d.
267. **THE SCIENCE OF BUILDING:** An Elementary Treatise on the Principles of Construction. By E. WYNDHAM TARN, M.A. Lond. Third Edition, Revised and Enlarged. 3s. 6d. 1/2
271. **VENTILATION:** a Text-book to the Practice of the Art of Ventilating Buildings. By W. P. BUCHAN, R.P., Sanitary Engineer, Author of "Plumbing," &c. 3s. 6d. 1/2
272. **ROOF CARPENTRY;** Practical Lessons in the Framing of Wood Roofs. For the Use of Working Carpenters. By GEO. COLLINGS, Author of "Handrailing and Stairbuilding," &c. 2s. [Just published.
273. **THE PRACTICAL PLASTERER:** A Compendium of Plain and Ornamental Plaster Work. By WILFRED KEMP. 2s. [Just published.

SHIPBUILDING, NAVIGATION, ETC.

51. **NAVAL ARCHITECTURE.** An Exposition of the Elementary Principles. By J. PEAKE. Fifth Edition, with Plates. 3s. 6d. 1/2
- 53*. **SHIPS FOR OCEAN & RIVER SERVICE,** Elementary and Practical Principles of the Construction of. By H. A. SOMMERFELDT. 1s. 6d.
- 53** **AN ATLAS OF ENGRAVINGS** to Illustrate the above. Twelve large folding plates. Royal 4to, cloth. 7s. 6d.
54. **MASTING, MAST-MAKING, AND RIGGING OF SHIPS,** Also Tables of Spars, Rigging, Blocks; Chain, Wire, and Hemp Ropes, &c., relative to every class of vessels. By ROBERT KIPPING, N.A. 2s.

•• The 1/2 indicates that these vols. may be had strongly bound at 6d. extra.

Shipbuilding, Navigation, Marine Engineering, etc., *cont.*

- 54*. **IRON SHIP-BUILDING.** With Practical Examples and Details.
By JOHN GRANTHAM, C.E. Fifth Edition. 4s.
55. **THE SAILOR'S SEA BOOK:** a Rudimentary Treatise on Navigation. By JAMES GREENWOOD, B.A. With numerous Woodcuts and Coloured Plates. New and enlarged edition. By W. H. ROSSER. 2s. 6d.†
80. **MARINE ENGINES AND STEAM VESSELS.** By ROBERT MURRAY, C.E. Eighth Edition, thoroughly Revised, with Additions by the Author and by GEORGE CARLISLE, C.E. 4s. 6d. limp; 5s. cloth boards.
- 83bis. **THE FORMS OF SHIPS AND BOATS.** By W. BLAND. Eighth Edition, Revised, with numerous Illustrations and Models. 1s. 6d.
99. **NAVIGATION AND NAUTICAL ASTRONOMY,** in Theory and Practice. By Prof. J. R. YOUNG. New Edition. 2s. 6d.
106. **SHIPS' ANCHORS,** a Treatise on. By G. COTSELL, N.A. 1s. 6d.
149. **SAILS AND SAIL-MAKING.** With Draughting, and the Centre of Effort of the Sails; Weights and Sizes of Ropes; Mastng, Rigger, and Sails of Steam Vessels, &c. 1st Edition. By R. KIPPING, N.A., 2s. 6d.†
155. **ENGINEER'S GUIDE TO THE ROYAL & MERCANTILE NAVIES.** By a PRACTICAL ENGINEER. Revised by D. F. MC CARTHY. 3s.
55. **PRACTICAL NAVIGATION.** Consisting of The Sailor's Sea-Book. By JAMES GREENWOOD and W. H. ROSSER. Together with the requisite Mathematical and Nautical Tables for the Working of the Problems. By H. LAW, C.E., and Prof. J. R. YOUNG. 7s. Half-bound.

AGRICULTURE, GARDENING, ETC.

- 61*. **A COMPLETE READY RECKONER FOR THE ADMEASUREMENT OF LAND,** &c. By A. ARMAN. Third Edition, revised and extended by C. NORRIS, Surveyor, Valuer, &c. 2s.
131. **MILLER'S, CORN MERCHANT'S, AND FARMER'S READY RECKONER.** Second Edition, with a Price List of Modern Flour-Mill Machinery, by W. S. HUTTON, C.E. 2s.
140. **SOILS, MANURES, AND CROPS.** (Vol. 1. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s.
141. **FARMING & FARMING ECONOMY,** Notes, Historical and Practical, on. (Vol. 2. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. 3s.
142. **STOCK; CATTLE, SHEEP, AND HORSES.** (Vol. 3. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s. 6d.
145. **DAIRY, PIGS, AND POULTRY,** Management of the. By R. SCOTT BURN. (Vol. 4. OUTLINES OF MODERN FARMING.) 2s.
146. **UTILIZATION OF SEWAGE, IRRIGATION, AND RECLAMATION OF WASTE LAND.** (Vol. 5. OUTLINES OF MODERN FARMING.) By R. SCOTT BURN. Woodcuts. 2s. 6d.
- *. Nos. 140-1-2-5-6, in *One Vol., handsomely half-bound, entitled "OUTLINES OF MODERN FARMING."* By ROBERT SCOTT BURN. Price 12s.
177. **FRUIT TREES,** The Scientific and Profitable Culture of. From the French of DU BREUIL. Revised by GEO. GLENNY. 187 Woodcuts. 3s. 6d.†
198. **SHEEP; THE HISTORY, STRUCTURE, ECONOMY, AND DISEASES OF.** By W. C. SPOONER, M.R.V.C., &c. Fifth Edition, enlarged, including Specimens of New and Improved Breeds. 3s. 6d.†
201. **KITCHEN GARDENING MADE EASY.** By GEORGE M. F. GLENNY. Illustrated. 1s. 6d.†
207. **OUTLINES OF FARM MANAGEMENT, and the Organization of Farm Labour.** By R. SCOTT BURN. 2s. 6d.†
208. **OUTLINES OF LANDED ESTATES MANAGEMENT.** By R. SCOTT BURN. 2s. 6d.
- *. Nos. 207 & 208 in *One Vol., handsomely half-bound, entitled "OUTLINES OF LANDED ESTATES AND FARM MANAGEMENT."* By R. SCOTT BURN. Price 6s.

† The † indicates that these vols. may be had strongly bound at 6d. extra.

Agriculture, Gardening, etc., continued.

- 209. THE TREE PLANTER AND PLANT PROPAGATOR.** A Practical Manual on the Propagation of Forest Trees, Fruit Trees, Flowering Shrubs, Flowering Plants, &c. By SAMUEL WOOD. 2s.
- 210. THE TREE PRUNER.** A Practical Manual on the Pruning of Fruit Trees, including also their Training and Renovation; also the Pruning of Shrubs, Climbers, and Flowering Plants. By SAMUEL WOOD. 1s. 6d.
- * Nos. 209 & 210 in *One Vol.*, handsomely half-bound, entitled "THE TREE PLANTER, PROPAGATOR, AND PRUNER." By SAMUEL WOOD. Price 3s. 6d.
- 218. THE HAY AND STRAW MEASURER:** Being New Tables for the Use of Auctioneers, Valuers, Farmers, Hay and Straw Dealers, &c. By JOHN STEELE. Fifth Edition. 2s.
- 222. SUBURBAN FARMING.** The Laying-out and Cultivation of Farms, adapted to the Produce of Milk, Butter, and Cheese, Eggs, Poultry, and Pigs. By Prof. JOHN DONALDSON and R. SCOTT BURN. 3s. 6d.†
- 231. THE ART OF GRAFTING AND BUDDING.** By CHARLES BALLET. With Illustrations. 2s. 6d.†
- 232. COTTAGE GARDENING;** or, Flowers, Fruits, and Vegetables for Small Gardens. By E. HOBDAV. 1s. 6d.
- 233. GARDEN RECEIPTS.** Edited by CHARLES W. QUIN. 1s. 6d.
- 234. MARKET AND KITCHEN GARDENING.** By C. W. SHAW, late Editor of "Gardening Illustrated." 3s.†
- 239. DRAINING AND EMBANKING.** A Practical Treatise, embodying the most recent experience in the Application of Improved Methods. By JOHN SCOTT, late Professor of Agriculture and Rural Economy at the Royal Agricultural College, Cirencester. With 68 Illustrations. 1s. 6d.
- 240. IRRIGATION AND WATER SUPPLY.** A Treatise on Water Meadows, Sewage Irrigation, and Warming; the Construction of Wells, Ponds, and Reservoirs, &c. By Prof. JOHN SCOTT. With 34 Illus. 1s. 6d.
- 241. FARM ROADS, FENCES, AND GATES.** A Practical Treatise on the Roads, Tramways, and Waterways of the Farm; the Principles of Enclosures; and the different kinds of Fences, Gates, and Stiles. By Professor JOHN SCOTT. With 75 Illustrations. 1s. 6d.
- 242. FARM BUILDINGS.** A Practical Treatise on the Buildings necessary for various kinds of Farms, their Arrangement and Construction, with Plans and Estimates. By Prof. JOHN SCOTT. With 105 Illus. 2s.
- 243. BARN IMPLEMENTS AND MACHINES.** A Practical Treatise on the Application of Power to the Operations of Agriculture; and on various Machines used in the Threshing-barn, in the Stock-yard, and in the Dairy, &c. By Prof. J. SCOTT. With 123 Illustrations. 2s.
- 244. FIELD IMPLEMENTS AND MACHINES.** A Practical Treatise on the Varieties now in use, with Principles and Details of Construction, their Points of Excellence, and Management. By Professor JOHN SCOTT. With 138 Illustrations. 2s.
- 245. AGRICULTURAL SURVEYING.** A Practical Treatise on Land Surveying, Levelling, and Setting-out; and on Measuring and Estimating Quantities, Weights, and Values of Materials, Produce, Stock, &c. By Prof. JOHN SCOTT. With 62 Illustrations. 1s. 6d.
- * Nos. 239 to 245 in *One Vol.*, handsomely half-bound, entitled "THE COMPLETE TEXT-BOOK OF FARM ENGINEERING." By Professor JOHN SCOTT. Price 12s.
- 250. MEAT PRODUCTION.** A Manual for Producers, Distributors, &c. By JOHN EWART. 2s. 6d.†
- 266. BOOK-KEEPING FOR FARMERS & ESTATE OWNERS.** By J. M. WOODMAN, Chartered Accountant. 2s. 6d. cloth limp; 3s. 6d. cloth boards.

 The † indicates that these vols. may be had strongly bound at 6d. extra.

LONDON: CROSBY LOCKWOOD AND SON,

MATHEMATICS, ARITHMETIC, ETC.

32. **MATHEMATICAL INSTRUMENTS**, a Treatise on; Their Construction, Adjustment, Testing, and Use concisely Explained. By J. F. HEATHER, M.A. Fourteenth Edition, revised, with additions, by A. T. WALMSLEY, M.I.C.E., Fellow of the Surveyors' Institution. Original Edition, in 1 vol., Illustrated. 2s.†
- *.* In ordering the above, be careful to say, "Original Edition" (No. 32), to distinguish it from the Enlarged Edition in 3 vols. (Nos. 168-9-70.)
76. **DESCRIPTIVE GEOMETRY**, an Elementary Treatise on; with a Theory of Shadows and of Perspective, extracted from the French of G. MONGE. To which is added, a description of the Principles and Practice of Isometrical Projection. By J. F. HEATHER, M.A. With 14 Plates. 2s.
178. **PRACTICAL PLANE GEOMETRY**: giving the Simplest Modes of Constructing Figures contained in one Plane and Geometrical Construction of the Ground. By J. F. HEATHER, M.A. With 215 Woodcuts. 2s.
83. **COMMERCIAL BOOK-KEEPING**. With Commercial Phrases and Forms in English, French, Italian, and German. By JAMES HADDON, M.A., Arithmetical Master of King's College School, London. 1s. 6d.
84. **ARITHMETIC**, a Rudimentary Treatise on: with full Explanations of its Theoretical Principles, and numerous Examples for Practice. By Professor J. R. YOUNG. Eleventh Edition. 1s. 6d.
- 84*. A KEY to the above, containing Solutions in full to the Exercises, together with Comments, Explanations, and Improved Processes, for the Use of Teachers and Unassisted Learners. By J. R. YOUNG. 1s. 6d.
85. **EQUATIONAL ARITHMETIC**, applied to Questions of Interest, Annuities, Life Assurance, and General Commerce; with various Tables by which all Calculations may be greatly facilitated. By W. HIPPLEY. 2s.
86. **ALGEBRA**, the Elements of. By JAMES HADDON, M.A. With Appendix, containing miscellaneous Investigations, and a Collection of Problems in various parts of Algebra. 2s.
- 86*. A KEY AND COMPANION to the above Book, forming an extensive repository of Solved Examples and Problems in Illustration of the various Expedients necessary in Algebraical Operations. By J. R. YOUNG. 1s. 6d.
88. **EUCLID, THE ELEMENTS OF**: with many additional Propositions and Explanatory Notes: to which is prefixed, an Introductory Essay on Logic. By HENRY LAW, C.E. 2s. 6d.†
- *.* Sold also separately, viz.:—
88. EUCLID, The First Three Books. By HENRY LAW, C.E. 1s. 6d.
89. EUCLID, Books 4, 5, 6, 11, 12. By HENRY LAW, C.E. 1s. 6d.
90. **ANALYTICAL GEOMETRY AND CONIC SECTIONS**, By JAMES HANN. A New Edition, by Professor J. R. YOUNG. 2s.†
91. **PLANE TRIGONOMETRY**, the Elements of. By JAMES HANN, formerly Mathematical Master of King's College, London. 1s. 6d.
92. **SPHERICAL TRIGONOMETRY**, the Elements of. By JAMES HANN. Revised by CHARLES H. DOWLING, C.E. 1s.
- *.* Or with "The Elements of Plane Trigonometry," in One Volume, 2s. 6d.
93. **MENSURATION AND MEASURING**. With the Mensuration and Levelling of Land for the Purposes of Modern Engineering. By T. BAKER, C.E. New Edition by E. NUGENT, C.E. Illustrated. 1s. 6d.
101. **DIFFERENTIAL CALCULUS**, Elements of the. By W. S. B. WOOLHOUSE, F.R.A.S., &c. 1s. 6d.
102. **INTEGRAL CALCULUS**, Rudimentary Treatise on the. By HOMERSHAM COX, B.A. Illustrated. 1s.
136. **ARITHMETIC**, Rudimentary, for the Use of Schools and Self-Instruction. By JAMES HADDON, M.A. Revised by A. ARMAN. 1s. 6d.
137. A KEY TO HADDON'S RUDIMENTARY ARITHMETIC. By A. ARMAN. 1s. 6d.

† The † indicates that these vols. may be had strongly bound at 6d. extra.

Mathematics, Arithmetic, etc., continued.

168. **DRAWING AND MEASURING INSTRUMENTS.** Including—I. Instruments employed in Geometrical and Mechanical Drawing, and in the Construction, Copying, and Measurement of Maps and Plans. II. Instruments used for the purposes of Accurate Measurement, and for Arithmetical Computations. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.
169. **OPTICAL INSTRUMENTS.** Including (more especially) Telescopes, Microscopes, and Apparatus for producing copies of Maps and Plans by Photography. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.
170. **SURVEYING AND ASTRONOMICAL INSTRUMENTS.** Including—I. Instruments Used for Determining the Geometrical Features of a portion of Ground. II. Instruments Employed in Astronomical Observations. By J. F. HEATHER, M.A. Illustrated. 1s. 6d.
- *. *The above three volumes form an enlargement of the Author's original work "Mathematical Instruments." (See No. 32 in the Series.)*
168. } **MATHEMATICAL INSTRUMENTS.** By J. F. HEATHER,
169. } M.A. Enlarged Edition, for the most part entirely re-written. The 3 Parts as
170. } above, in One thick Volume. With numerous Illustrations. 4s. 6d.†
158. **THE SLIDE RULE, AND HOW TO USE IT;** containing full, easy, and simple Instructions to perform all Business Calculations with unexampled rapidity and accuracy. By CHARLES HOARE, C.E. Sixth Edition. With a Slide Rule in tuck of cover. 2s. 6d.†
196. **THEORY OF COMPOUND INTEREST AND ANNUITIES;** with Tables of Logarithms for the more Difficult Computations of Interest, Discount, Annuities, &c. By EDOR THOMAN. Fourth Edition. 4s.†
199. **THE COMPENDIOUS CALCULATOR;** or, Easy and Concise Methods of Performing the various Arithmetical Operations required in Commercial and Business Transactions; together with Useful Tables. By D. O'GORMAN. Twenty-seventh Edition, carefully revised by C. NORRIS. 2s. 6d., cloth limp; 3s. 6d., strongly half-bound in leather.
204. **MATHEMATICAL TABLES,** for Trigonometrical, Astronomical, and Nautical Calculations; to which is prefixed a Treatise on Logarithms. By HENRY LAW, C.E. Together with a Series of Tables for Navigation and Nautical Astronomy. By Prof. J. R. YOUNG. New Edition. 4s.
- 204*. **LOGARITHMS.** With Mathematical Tables for Trigonometrical, Astronomical, and Nautical Calculations. By HENRY LAW, M.Inst.C.E. New and Revised Edition. (Forming part of the above Work). 3s.
221. **MEASURES, WEIGHTS, AND MONIES OF ALL NATIONS,** and an Analysis of the Christian, Hebrew, and Mahometan Calendars. By W. S. B. WOOLHOUSE, F.R.A.S., F.S.S. Seventh Edition, 2s. 6d.†
227. **MATHEMATICS AS APPLIED TO THE CONSTRUCTIVE ARTS.** Illustrating the various processes of Mathematical Investigation, by means of Arithmetical and Simple Algebraical Equations and Practical Examples. By FRANCIS CAMPIN, C.E. Second Edition. 3s.†

PHYSICAL SCIENCE, NATURAL PHILOSOPHY, ETC.

1. **CHEMISTRY.** By Professor GEORGE FOWNES, F.R.S. With an Appendix on the Application of Chemistry to Agriculture. 1s.
2. **NATURAL PHILOSOPHY,** Introduction to the Study of. By C. TOMLINSON. Woodcuts. 1s. 6d.
6. **MECHANICS,** Rudimentary Treatise on. By CHARLES TOMLINSON. Illustrated. 1s. 6d.
7. **ELECTRICITY;** showing the General Principles of Electrical Science, and the purposes to which it has been applied. By Sir W. SNOW HARRIS, F.R.S., &c. With Additions by R. SABINE, C.E., F.S.A. 1s. 6d.
- 7*. **GALVANISM.** By Sir W. SNOW HARRIS. New Edition by ROBERT SABINE, C.E., F.S.A. 1s. 6d.
8. **MAGNETISM;** being a concise Exposition of the General Principles of Magnetical Science. By Sir W. SNOW HARRIS. New Edition, revised by H. M. NODD, Ph.D. With 165 Woodcuts. 3s. 6d.†

† The † indicates that these vols. may be had strongly bound at 6d. extra.

Physical Science, Natural Philosophy, etc., continued.

11. **THE ELECTRIC TELEGRAPH**; its History and Progress; with Descriptions of some of the Apparatus. By R. SABINE, C.E., F.S.A. 3s.
12. **PNEUMATICS**, including Acoustics and the Phenomena of Wind Currents, for the Use of Beginners. By CHARLES TOMLINSON, F.R.S. Fourth Edition, enlarged. Illustrated. 1s. 6d.
72. **MANUAL OF THE MOLLUSCA**; a Treatise on Recent and Fossil Shells. By Dr. S. P. WOODWARD, A.L.S. Fourth Edition. With Plates and 300 Woodcuts. 7s. 6d., cloth.
96. **ASTRONOMY**. By the late Rev. ROBERT MAIN, M.A. Third Edition, by WILLIAM THYNNE LYNN, B.A., F.R.A.S. 2s.
97. **STATICS AND DYNAMICS**, the Principles and Practice of; embracing also a clear development of Hydrostatics, Hydrodynamics, and Central Forces. By T. BAKER, C.E. Fourth Edition. 1s. 6d.
173. **PHYSICAL GEOLOGY**, partly based on Major-General PORTLOCK's "Rudiments of Geology." By RALPH TATE, A.L.S., &c. Woodcuts. 2s.
174. **HISTORICAL GEOLOGY**, partly based on Major-General PORTLOCK's "Rudiments." By RALPH TATE, A.L.S., &c. Woodcuts. 2s. 6d.
173. **RUDIMENTARY TREATISE ON GEOLOGY**, Physical and Historical. Partly based on Major-General PORTLOCK's "Rudiments of Geology." By RALPH TATE, A.L.S., F.G.S., &c. In One Volume. 4s. 6d.‡
183. **ANIMAL PHYSICS**, Handbook of. By Dr. LARDNER, D.C.L., & formerly Professor of Natural Philosophy and Astronomy in University College, Lond. With 520 Illustrations. In One Vol. 7s. 6d., cloth boards.
184. **ANIMAL PHYSICS**. By Dr. LARDNER. Part I., Chapters I.—VII. 4s.
184. **ANIMAL PHYSICS**. By Dr. LARDNER. Part II., Chapters VIII.—XVIII. 3s.
269. **LIGHT**: an Introduction to the Science of Optics, for the Use of Students of Architecture, Engineering, and other Applied Sciences. By E. WYNNDHAM TARN, M.A. 1s. 6d. [Just published.]

FINE ARTS.

20. **PERSPECTIVE FOR BEGINNERS**. Adapted to Young Students and Amateurs in Architecture, Painting, &c. By GEORGE PYNE. 2s.
40. **GLASS STAINING, AND THE ART OF PAINTING ON GLASS**. From the German of Dr. GESSERT and EMANUEL OTTO FROMBERG. With an Appendix on THE ART OF ENAMELLING. 2s. 6d.
69. **MUSIC**, A Rudimentary and Practical Treatise on. With numerous Examples. By CHARLES CHILD SPENCER. 2s. 6d.
71. **PIANOFORTE**, The Art of Playing the. With numerous Exercises & Lessons from the Best Masters. By CHARLES CHILD SPENCER. 1s. 6d.
- 69-71. **MUSIC & THE PIANOFORTE**. In one vol. Half bound, 5s.
181. **PAINTING POPULARLY EXPLAINED**, including Fresco, Oil, Mosaic, Water Colour, Water-Glass, Tempera, Encaustic, Miniature, Painting on Ivory, Vellum, Pottery, Enamel, Glass, &c. With Historical Sketches of the Progress of the Art by THOMAS JOHN GULLICK, assisted JOHN TIMBS, F.S.A. Sixth Edition, revised and enlarged. 5s.‡
186. **A GRAMMAR OF COLOURING**, applied to Decorative Painting and the Arts. By GEORGE FIELD. New Edition, enlarged and adapted to the Use of the Ornamental Painter and Designer. By ELLIS A. DAVIDSON. With two new Coloured Diagrams, &c. 3s.‡
246. **A DICTIONARY OF PAINTERS, AND HANDBOOK FOR PICTURE AMATEURS**; including Methods of Painting, Cleaning, Relining and Restoring, Schools of Painting, &c. With Notes on the Copyists and Imitators of each Master. By PHILIPPE DARYL. 2s. 6d.‡

183 The ‡ indicates that these vols. may be had strongly bound at 6d. extra.

INDUSTRIAL AND USEFUL ARTS.

23. **BRICKS AND TILES**, Rudimentary Treatise on the Manufacture of. By E. DOBSON, M.R.I.B.A. Illustrated, 3s.†
67. **CLOCKS, WATCHES, AND BELLS**, a Rudimentary Treatise on. By Sir EDMUND BECKETT, LL.D., Q.C. Seventh Edition, revised and enlarged. 4s. 6d. limp; 5s. 6d. cloth boards.
- 83*. **CONSTRUCTION OF DOOR LOCKS**. Compiled from the Papers of A. C. HOBBS, and Edited by CHARLES TOMLINSON, F.R.S. 2s. 6d.
162. **THE BRASS FOUNDER'S MANUAL**; Instructions for Modelling, Pattern-Making, Moulding, Turning, Filing, Burnishing, Bronzing, &c. With copious Receipts, &c. By WALTER GRAHAM. 2s.†
205. **THE ART OF LETTER PAINTING MADE EASY**. By J. G. BADENOCH. Illustrated with 12 full-page Engravings of Examples. 1s. 6d.
215. **THE GOLDSMITH'S HANDBOOK**, containing full Instructions for the Alloying and Working of Gold. By GEORGE E. GEE, 3s.†
225. **THE SILVERSMITH'S HANDBOOK**, containing full Instructions for the Alloying and Working of Silver. By GEORGE E. GEE. 3s.†
- *. *The two preceding Works, in One handsome Vol., half-bound, entitled "THE GOLDSMITH'S & SILVERSMITH'S COMPLETE HANDBOOK," 7s.*
249. **THE HALL-MARKING OF JEWELLERY PRACTICALLY CONSIDERED**. By GEORGE E. GEE. 3s.†
224. **COACH BUILDING**, A Practical Treatise, Historical and Descriptive. By J. W. BURGESS. 2s. 6d.†
235. **PRACTICAL ORGAN BUILDING**. By W. E. DICKSON, M.A., Precentor of Ely Cathedral. Illustrated. 2s. 6d.†
262. **THE ART OF BOOT AND SHOEMAKING**. By JOHN BEDFORD LENO. Numerous Illustrations. Third Edition. 2s.
263. **MECHANICAL DENTISTRY**: A Practical Treatise on the Construction of the Various Kinds of Artificial Dentures, with Formulæ, Tables, Receipts, &c. By CHARLES HUNTER. Third Edition. 3s.†
270. **WOOD ENGRAVING**: A Practical and Easy Introduction to the Study of the Art. By W. N. BROWN. 1s. 6d.

MISCELLANEOUS VOLUMES.

36. **A DICTIONARY OF TERMS used in ARCHITECTURE, BUILDING, ENGINEERING, MINING, METALLURGY, ARCHÆOLOGY, the FINE ARTS, &c.** By JOHN WEALE. Sixth Edition. Revised by ROBERT HUNT, F.R.S. Illustrated. 5s. limp; 6s. cloth boards.
50. **LABOUR CONTRACTS**. A Popular Handbook on the Law of Contracts for Works and Services. By DAVID GIBBONS. Fourth Edition, Revised, with Appendix of Statutes by T. F. UTILEY, Solicitor, 3s. 6d. cloth.
112. **MANUAL OF DOMESTIC MEDICINE**. By R. GOODING, B.A., M.D. A Family Guide in all Cases of Accident and Emergency 2s.
- 112*. **MANAGEMENT OF HEALTH**. A Manual of Home and Personal Hygiene. By the Rev. JAMES BAIRD, B.A. 1s.
150. **LOGIC**, Pure and Applied. By S. H. EMMENS. 1s. 6d.
153. **SELECTIONS FROM LOCKE'S ESSAYS ON THE HUMAN UNDERSTANDING**. With Notes by S. H. EMMENS. 2s.
154. **GENERAL HINTS TO EMIGRANTS**. 2s.
157. **THE EMIGRANT'S GUIDE TO NATAL**. By R. MANN. 2s.
193. **HANDBOOK OF FIELD FORTIFICATION**. By Major W. W. KNOLLYS, F.R.G.S. With 163 Woodcuts. 3s.†
194. **THE HOUSE MANAGER**: Being a Guide to Housekeeping. Practical Cookery, Pickling and Preserving, Household Work, Dairy Management, &c. By AN OLD HOUSEKEEPER. 3s. 6d.†
194. **HOUSE BOOK (The)**. Comprising:—I. THE HOUSE MANAGER. 112 & By an OLD HOUSEKEEPER. II. DOMESTIC MEDICINE. By R. GOODING, M.D.
- 112*. III. MANAGEMENT OF HEALTH. By J. BAIRD. In One Vol., half-bound, 6s.

† The † indicates that these vols. may be had strongly bound at 6d. extra.

EDUCATIONAL AND CLASSICAL SERIES.

HISTORY.

1. **England, Outlines of the History of;** more especially with reference to the Origin and Progress of the English Constitution. By WILLIAM DOUGLAS HAMILTON, F.S.A., of Her Majesty's Public Record Office. 4th Edition, revised. 5s.; cloth boards, 6s.
5. **Greece, Outlines of the History of;** in connection with the Rise of the Arts and Civilization in Europe. By W. DOUGLAS HAMILTON, of University College, London, and EDWARD LEVIEN, M.A., of Balliol College, Oxford. 2s. 6d.; cloth boards, 3s. 6d.
7. **Rome, Outlines of the History of;** from the Earliest Period to the Christian Era and the Commencement of the Decline of the Empire. By EDWARD LEVIEN, of Balliol College, Oxford. Map, 2s. 6d.; cl. bds. 3s. 6d.
9. **Chronology of History, Art, Literature, and Progress,** from the Creation of the World to the Present Time. The Continuation by W. D. HAMILTON, F.S.A. 3s.; cloth boards, 3s. 6d.
50. **Dates and Events in English History,** for the use of Candidates in Public and Private Examinations. By the Rev. E. RAND. 1s.

ENGLISH LANGUAGE AND MISCELLANEOUS.

11. **Grammar of the English Tongue, Spoken and Written.** With an Introduction to the Study of Comparative Philology. By HYDE CLARKE, D.C.L. Fifth Edition. 1s. 6d.
12. **Dictionary of the English Language, as Spoken and Written.** Containing above 100,000 Words. By HYDE CLARKE, D.C.L. 3s. 6d.; cloth boards, 4s. 6d.; complete with the GRAMMAR, cloth bds., 5s. 6d.
48. **Composition and Punctuation, familiarly Explained** for those who have neglected the Study of Grammar. By JUSTIN BRENNAN. 18th Edition. 1s. 6d.
49. **Derivative Spelling-Book:** Giving the Origin of Every Word from the Greek, Latin, Saxon, German, Teutonic, Dutch, French, Spanish, and other Languages; with their present Acceptation and Pronunciation. By J. ROWBOTHAM, F.R.A.S. Improved Edition. 1s. 6d.
51. **The Art of Extempore Speaking:** Hints for the Pulpit, the Senate, and the Bar. By M. BAUTAIN, Vicar-General and Professor at the Sorbonne. Translated from the French. 8th Edition, carefully corrected. 2s. 6d.
54. **Analytical Chemistry, Qualitative and Quantitative, a Course of.** To which is prefixed, a Brief Treatise upon Modern Chemical Nomenclature and Notation. By WM. W. PINK and GEORGE E. WEBSTER. 2s.

THE SCHOOL MANAGERS' SERIES OF READING BOOKS,

Edited by the Rev. A. R. GRANT, Rector of Hitcham, and Honorary Canon of Ely; formerly H.M. Inspector of Schools.

INTRODUCTORY PRIMER, 3d.

	s.	d.		s.	d.
FIRST STANDARD . . .	0	6	FOURTH STANDARD . . .	1	2
SECOND " . . .	0	10	FIFTH " . . .	1	6
THIRD " . . .	1	0	SIXTH " . . .	1	6

LESSONS FROM THE BIBLE. Part I. Old Testament. 1s.

LESSONS FROM THE BIBLE. Part II. New Testament, to which is added THE GEOGRAPHY OF THE BIBLE, for very young Children. By Rev. C. THORNTON FORSTER. 1s. 2d. *.* Or the Two Parts in One Volume. 2s.

FRENCH.

24. **French Grammar.** With Complete and Concise Rules on the Genders of French Nouns. By G. L. STRAUSS, Ph.D. 1s. 6d.
 25. **French-English Dictionary.** Comprising a large number of New Terms used in Engineering, Mining, &c. By ALFRED ELWES. 1s. 6d.
 26. **English-French Dictionary.** By ALFRED ELWES. 2s.
 25, 26. **French Dictionary** (as above). Complete, in One Vol., 3s.; cloth boards, 3s. 6d. *.* Or with the GRAMMAR, cloth boards, 4s. 6d.
 47. **French and English Phrase Book:** containing Introductory Lessons, with Translations, several Vocabularies of Words, a Collection of suitable Phrases, and Easy Familiar Dialogues. 1s. 6d.

GERMAN.

39. **German Grammar.** Adapted for English Students, from Heyse's Theoretical and Practical Grammar, by Dr. G. L. STRAUSS. 1s. 6d.
 40. **German Reader:** A Series of Extracts, carefully culled from the most approved Authors of Germany; with Notes, Philological and Explanatory. By G. L. STRAUSS, Ph.D. 1s.
 41-43. **German Trilogot Dictionary.** By N. E. S. A. HAMILTON. In Three Parts. Part I. German-French-English. Part II. English-German-French. Part III. French-German-English. 3s., or cloth boards, 4s.
 41-43. **German Trilogot Dictionary** (as above), together with German & 39. **Grammar** (No. 39), in One Volume, cloth boards, 5s.

ITALIAN.

27. **Italian Grammar,** arranged in Twenty Lessons, with a Course of Exercises. By ALFRED ELWES. 1s. 6d.
 28. **Italian Trilogot Dictionary,** wherein the Genders of all the Italian and French Nouns are carefully noted down. By ALFRED ELWES. Vol. 1. Italian-English-French. 2s. 6d.
 30. **Italian Trilogot Dictionary.** By A. ELWES. Vol. 2. English-French-Italian. 2s. 6d.
 32. **Italian Trilogot Dictionary.** By ALFRED ELWES. Vol. 3. French-Italian-English. 2s. 6d.
 28, 30, 32. **Italian Trilogot Dictionary** (as above). In One Vol., 7s. 6d. Cloth boards.

SPANISH AND PORTUGUESE.

34. **Spanish Grammar,** in a Simple and Practical Form. With a Course of Exercises. By ALFRED ELWES. 1s. 6d.
 35. **Spanish-English and English-Spanish Dictionary.** Including a large number of Technical Terms used in Mining, Engineering, &c. with the proper Accents and the Gender of every Noun. By ALFRED ELWES 4s.; cloth boards, 5s. *.* Or with the GRAMMAR, cloth boards, 6s.
 55. **Portuguese Grammar,** in a Simple and Practical Form. With a Course of Exercises. By ALFRED ELWES. 1s. 6d.
 56. **Portuguese-English and English-Portuguese Dictionary.** Including a large number of Technical Terms used in Mining, Engineering, &c., with the proper Accents and the Gender of every Noun. By ALFRED ELWES. Second Edition, Revised, 5s.; cloth boards, 6s. *.* Or with the GRAMMAR, cloth boards, 7s.

HEBREW.

- 46*. **Hebrew Grammar.** By Dr. BRESSLAU. 1s. 6d.
 44. **Hebrew and English Dictionary,** Biblical and Rabbinical; containing the Hebrew and Chaldee Roots of the Old Testament Post-Rabbinical Writings. By Dr. BRESSLAU. 6s.
 46. **English and Hebrew Dictionary.** By Dr. BRESSLAU. 3s.
 44, 46. **Hebrew Dictionary** (as above), in Two Vols., complete, with 46*. the GRAMMAR, cloth boards, 12s.

LATIN.

19. **Latin Grammar.** Containing the Inflections and Elementary Principles of Translation and Construction. By the Rev. THOMAS GOODWIN, M.A., Head Master of the Greenwich Proprietary School. 1s. 6d.
20. **Latin-English Dictionary.** By the Rev. THOMAS GOODWIN, M.A. 2s.
22. **English-Latin Dictionary;** together with an Appendix of French and Italian Words which have their origin from the Latin. By the Rev. THOMAS GOODWIN, M.A. 1s. 6d.
- 20, 22. **Latin Dictionary** (as above). Complete in One Vol., 3s. 6d. cloth boards, 4s. 6d. * Or with the GRAMMAR, cloth boards, 5s. 6d.

LATIN CLASSICS. With Explanatory Notes in English.

1. **Latin Delectus.** Containing Extracts from Classical Authors, with Genealogical Vocabularies and Explanatory Notes, by H. YOUNG. 1s. 6d.
2. **Cæsar's Commentarii de Bello Gallico.** Notes, and a Geographical Register for the Use of Schools, by H. YOUNG. 2s.
3. **Cornelius Nepos.** With Notes. By H. YOUNG. 1s.
4. **Virgilli Maronis Bucolica et Georgica.** With Notes on the Bucolics by W. RUSHTON, M.A., and on the Georgics by H. YOUNG. 1s. 6d.
5. **Virgilli Maronis Æneis.** With Notes, Critical and Explanatory, by H. YOUNG. New Edition, revised and improved. With copious Additional Notes by Rev. T. H. L. LEARY, D.C.L., formerly Scholar of Brasenose College, Oxford. 3s.
- 5* ——— Part 1. Books i.—vi., 1s. 6d.
- 5** ——— Part 2. Books vii.—xii., 2s.
6. **Horace; Odes, Epode, and Carmen Sæculare.** Notes by H. YOUNG. 1s. 6d.
7. **Horace; Satires, Epistles, and Ars Poetica.** Notes by W. BROWN-RIGG SMITH, M.A., F.R.G.S. 1s. 6d.
8. **Sallustii Crispi Catalina et Bellum Jugurthinum.** Notes, Critical and Explanatory, by W. M. DONNE, B.A., Trin. Coll., Cam. 1s. 6d.
9. **Terentii Andria et Heautontimorumenos.** With Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 1s. 6d.
10. **Terentii Adelphi, Hecyra, Phormio.** Edited, with Notes, Critical and Explanatory, by the Rev. JAMES DAVIES, M.A. 2s.
11. **Terentii Eunuchus, Comœdia.** Notes, by Rev. J. DAVIES, M.A. 1s. 6d.
12. **Ciceronis Oratio pro Sexto Roscio Amerino.** Edited, with an Introduction, Analysis, and Notes, Explanatory and Critical, by the Rev. JAMES DAVIES, M.A. 1s. 6d.
13. **Ciceronis Orationes in Catilinam, Verrem, et pro Archia.** With Introduction, Analysis, and Notes, Explanatory and Critical, by Rev. T. H. L. LEARY, D.C.L. formerly Scholar of Brasenose College, Oxford. 1s. 6d.
14. **Ciceronis Cato Major, Lælius, Brutus, sive de Senectute, de Amicitia, de Claris Oratoribus Dialogi.** With Notes by W. BROWN-RIGG SMITH, M.A., F.R.G.S. 2s.
16. **Livy: History of Rome.** Notes by H. YOUNG and W. B. SMITH, M.A. Part 1. Books i., ii., 1s. 6d.
- 16* ——— Part 2. Books iii., iv., v., 1s. 6d.
17. ——— Part 3. Books xxi., xxii., 1s. 6d.
19. **Latin Verse Selections,** from Catullus, Tibullus, Propertius, and Ovid. Notes by W. B. DONNE, M.A., Trinity College, Cambridge. 2s.
20. **Latin Prose Selections,** from Varro, Columella, Vitruvius, Seneca, Quintilian, Florus, Velleius Paterculus, Valerius Maximus, Suetonius, Apuleius, &c. Notes by W. B. DONNE, M.A. 2s.
21. **Juvenalis Satiræ.** With Prolegomena and Notes by T. H. S. ESCOTT, B.A., Lecturer on Logic at King's College, London. 2s.

